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Photo by Underwood & Underwood, N. Y.

Inspecting the bore of a military rifle barrel in a government armory

THE MILITARY RIFLE—[See page 4]

The Resources of the Russian Empire*

A Country of Great Economic Importance to America

By E. K. Reynolds

One of the far-reaching results of the war in this country has been the stimulation of an interest in Russia. This is not exactly a new thing. Americans have for a long time been interested in the great writers, composers, and artists, as well as the politics of Russia. There was a time even, not long since, when Americans were more occupied with conditions in Russian prisons than in their own. But all that has little in common with this new interest, which is pointed toward the discovery of a new Russia, hitherto unsought and unknown—economic Russia. Politics and fiction are brushed aside, and Russia is being evaluated in terms of her economic possibilities. Americans are beginning to study the growth of the Russian Empire and its wealth in natural resources.

The story of the expansion of a country which has resulted in the largest compact political organization the world has ever seen is necessarily an interesting one. The beginnings of Russian history, like that of every country, are but vaguely known. The foundation stone of the Russian state was laid in Novgorod in 862 A. D., but it was a century or two earlier that a group of Eastern Slavs came down from the Carpathians and settled on the banks of the Dniepr. There they built up a flourishing trading state, with its center at Kiev. The Dniepr became the great trade route; amber from the Baltic, and furs, honey and wax from the forests along its banks were carried down to Constantinople, while gold, silver, stuffs, wine and fruits were brought up the river in return.

In those days of prosperity, the Eastern Slavs, later known as Russians, were free to develop their local institutions, and, according to all accounts, they governed themselves in an extremely democratic way. They had their princes, but these constituted little more than military leaders and were bound in every way by the will of their subjects as expressed through their common council. Then came the fateful day when the Russians had to sacrifice everything to stem the rising tide of Tatar invasion. They were defeated, but their dead bodies formed a rampart which checked the yellow hosts and saved Europe and Western civilization from their onslaught. The price that Russia had to pay for this and the real significance of her act are far from being fully appreciated by her western neighbors. Those same nations which have to thank her for almost their very existence can find nothing better to do, now that she is emerging from her bitter, century-long struggle to take her place in the front rank of the peoples of the world, than to make faces at her backwardness.

For Russia the Tatar invasion had the most terrible consequences. It meant the wiping out of the whole political organization which she had developed along such democratic lines. To escape the oppressive rule of the invaders, many returned to the Carpathians, to Galicia, but the majority moved to the northeast, from Kiev in the general direction of Moscow and the upper reaches of the Volga. Here they found themselves suddenly confronted with the grim task, first of conquering new homes from hostile Finnish tribes, then of wringing an existence from nature in the dark, endless forests and marshes of the North, fighting starvation and absorption year after year. These were the conditions under which the "Great Russians" came into being. Racially the same as the "Little Russians" of the lower Dniepr, their character underwent a change which has persisted to this day. The carefree, unrestrained gaiety of the early days, when they were a happy-go-lucky, prosperous nation of traders, was hammered out of them by the circumstances of their daily life, and the Great Russian peasant was born sturdy, resolute; watchful and mindful of every move of nature, he was ready for and resigned to any hardships.

In this new order of things, Moscow became the center of gravity in place of Kiev. Its geographical position justified this, because, being situated on a tributary of the Volga, which flows all through eastern Russia down to the Caspian, and at the same time being near the headwaters of the Dniepr, the trade route from the Baltic to the Black Sea, it naturally became the economic center of Russia. Moreover, with the fall of Kiev the religious center was shifted to Moscow. Finally, and this is the most important reason, it was the Prince of Moscow who had the perspicacity to insinuate himself into the good graces of the Tatar ruler and to learn from him the art of powerful, centralized government. He was made tax-collector for the khan, and in this way practically all the Russians were brought under his control. Then at a given moment he used the power vested in him by the Tatars to turn against his master and to refuse him further allegiance. This was the beginning of a long and bloody struggle. While in western Europe the arts and sciences were free to flourish and nations could progress, Russia had to keep her lonely vigil at the eastern gate.

Fighting step by step, the Russians followed the great plain to its limits, wandering up to the White Sea, eastward across the Volga to the Urals, and across the Urals into the level land of western Siberia. They spread in every direction, continually advancing their frontiers toward the sea, the sea which would be a barrier to their enemies and an outlet for their trade. They succeeded in establishing themselves definitely on the northern shore of the Black Sea, only to find themselves blocked at the Dardanelles. In the east they broke their way through the mountains of eastern Siberia to plant their flag on the shores of the Pacific. But the Pacific was three months' travel from Moscow. The Baltic then seemed to offer the solution to the problem, and Sweden was forced to cede the territory on which Petrograd now stands. This, in brief, is the story of the expansion of the Russian land from a settlement on the Dniepr, northward, southwards, eastward, to the Arctic Ocean, the Black Sea, the Caspian, the confines of China, and the shores of the Pacific.

At present the Russian Empire encompasses 42 degrees of latitude and no less than 173 degrees of longitude, that is to say, it doubles the extent of the United States in length and nearly triples it in breadth. The Empire State of New York could be easily set down in the 8,647,657 square miles of the Russian Empire's area 165 times; while Russia, west of the Urals alone, is 10 times the size of France, and 33 times the size of England and Wales. European Russia takes over one-half of Europe, and Asiatic Russia over one-third of all Asia. So we find Russia occupying more than one-seventh of the total land surface of the globe.

In discussing the various parts of this gigantic whole, custom has fixed a dividing line between east and west in the Ural Mountains. This boundary, however, is, like the equatorial line, more fictitious than real. European Russia and western Siberia are, generally speaking, one vast plain, which slopes on the north to the Arctic Ocean and on the south to the Black Sea and the Caspian. This great plain is barely broken by the Urals: in their central part, where the Trans-Siberian railroad crosses them, the ascent is so gradual that one is not in the least aware of ascending, until at a given moment a sign post is reached which points in one direction, "to Europe," in the other "to Asia." A slight change in the character of the vegetation is also noticed. But before and behind are the great sweeps of level country.

To the Asiatic side of the Urals the farmers from the other end of the plain have been flocking for years, in spite of the ill repute that accompanies a penal settlement. They find natural conditions very little different from the European side, but they find a virgin soil, a chance to start life afresh. They are usually prosperous and happy and less restricted by government regulations. These are the builders of the new Russia. In them there is all the living promise of the future. They have the backbone of the race; they are of the purest Russian stock; and, at the same time, as pioneers in a new country, their vision is broader, they are untrammeled by convention, they are as fresh and vigorous as the untamed nature around them.

Both here and in European Russia, life is more or less the same. That, too, is the result of the plain—allowing of no differences, the creator of endless monotony. You travel for days and days, north and south, east and west, without finding any appreciable variety in the landscape, unless it be a change from the log cabin of the forest region of the north and center to the white, plastered, thatched cottage of the southwest. This, of course, is a very general statement. There are distinct zones of vegetation, which vary, according to the climatic conditions, from the Arctic Circle to the Caucasus and Central Asia.

First of all in the extreme north, from the White Sea to Bering Strait, there lies the region of the tundras—waste frozen marshes stretching inland from the sea for from three hundred to a thousand miles. It is often difficult to determine the point separating the land from the sea, for the surface of the ground is frozen some forty feet deep; even the heat of summer can thaw only about two feet of top soil. The only possible vegetation consists of moss and a few berry bushes—scant food for the millions of birds and beasts of all kinds that flock northward in July and August to escape their enemy, the hunter. By the end of August, however, the heavy frosts set in, and the tundras become a barren, lifeless desert, covered with snow for hundreds of miles, with never a living speck of any kind on which to rest one's eyes.

To the south of the tundras is the great coniferous forest belt, which stretches from Finland to the Sea of Okhotsk. At its western end, where it is more settled, this is perhaps the most beautiful part of the great Russian plain. The countryside is dark with the shadows of the fir trees, but frequently shot with the light, lithe trunks of silver birches. The aspect of the land, too, is slightly rolling in parts, and cradled between these slight elevations there are thousands of charming little lakes fringed around with reeds.

In Siberia, the forest region is called the *taigá*, which means a vast, more or less unknown surface, covered with dense, impassable forests. Heavy underbrush, fallen trunks, and endless quantities of game are its chief characteristics. Comparatively little of the *taigá* has been reclaimed, that is, turned into farming land. One reason is that the climate here is so extreme and the winters so endlessly long. The cold is so intense that an occasional tree splits open, making a noise like the report of a pistol. It is so cold that the warmth from the body of a bird, as it rises from the ground, will leave a streak of steam. Added to this is the annoyance from the swarms of insects characteristic of Arctic summers. The pioneer settlers had to live in houses filled with smoke to get any relief from them, and they had to build huge bonfires in the pasture lands to protect the cattle.

Yet this *taigá* is one of the greatest treasures in Russia's long list of natural resources. In round figures it is said to represent ninety million acres of magnificent timber. That is less than one-tenth of all the timber resources of the Empire, which are estimated at one and a quarter billion acres. In addition to the great northern forest belt, there are extensive forests on the Urals and the Caucasus. The trees of the *taigá* are pines, firs, spruces, larches, and allied species, intermingled here and there with various kinds of birches, aspen, and a few other leafy trees. At its western end, in the central provinces of Russia, the *taigá* abuts upon the mixed deciduous forest which covers all of cool-temperate Europe. Oak, maple, elm, ash, and poplar are the chief trees. The Mediterranean vegetation of southern Crimea and the eastern Black Sea littoral contains such species as the cork-oak and the yew.

Even to guess at the actual value of these forests would be futile, for they are barely touched as yet. Nevertheless, Russia has exported yearly of late $81,800,000 worth of timber of various kinds, principally to England, Belgium, Germany and Austria—this in spite of the enormous home consumption. All northern and central Russia is built of wood, stone being scarce and inaccessible. It is said that all Russia burns down every seven years. The Russians use wood almost exclusively as fuel, both on the railroads and for heating. It is interesting that in renting an apartment one pays a round sum which includes so many cords of wood for heating purposes. The Russians also employ wood very extensively for utensils and implements of various kinds. Fortunately, there are forest preservation laws. These do not enforce the replacing of trees, as is the case, for instance, in Germany, but a forest cannot be cut more than once in a period of eighty years. In any case, Russia has an abundant supply of timber for the present and a good bit of the future in her great forest regions, enough for herself and her friends.

These same regions are a source of great wealth for a second reason. They are teeming with game of all kinds. Hunting, therefore, is naturally the means of support for many, whether Great Russian peasants in the west, Siberian hunters and trappers in the east, or wild tribesmen in the forests of the Urals or out-of-the-way places of the Empire. Here, again, it is impossible to ascertain the extent of the hunting done, except from the skins and birds that are brought to market. There are regular centers for trading in skins. Yakutsk in eastern Siberia is one of the largest markets, and there is a fair held in Irbit, in the Urals, every year, which is given up entirely to barter in skins. Here the traders buy up the sables and ermines for which the Ostiaks have hunted along the Ob, or the Tatars and Soiols in the Altai ranges, or the Yakuts in the region of the Yablonoi

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or Stanovoi Mountains. The variety in the game is astounding. The skins range from $10.00 for Arctic fox to $50.00 for dark sable. With this abundance of supply, it surprises at first that furs ready for wearing apparel should be so expensive in Russia. The reason for this is that no furs are dyed in Russia. The skins are sent mostly to Leipzig, prepared and dyed, and then shipped back to Russia, laden with duties.

On the outskirts of the forest zone, in the provinces of Vologda and Yaroslavl (east and southeast of Petrograd) and in the Baltic provinces, lies the great flax-growing country—4,050,000 acres given up solely to this industry. Flax has been grown here for centuries and has given to Russian linen its high reputation. The flax for the finer uses comes from the Baltic provinces and that for the coarser products principally from Vologda, the home of the strikingly beautiful Russian laces, drawn-work, and embroideries which have brought to the outside world a realization of the unusual artistic ability of the Russian peasant.

To the south of the forest zone in European Russia and western Siberia, lies the open country, usually known as the steppe region. At the very mention of the name "steppe" many assiduous readers of pseudo-Russian fiction will smile knowingly and conjure up visions of a Russian Wild West—overrun with ferocious Cossacks, and probably a sprinkling of Kalmyks. As a matter of fact, however, the wild riders of the plain have been superseded by the farmers. The plow has robbed the horses and sheep, even in the southernmost parts, of their fertile pastures. In traveling southward now one sees nothing but farm lands, fields of grain everywhere, until the very edge of the Black Sea is reached. The steppe is principally the granary of Russia. Hundreds and thousands of tons of wheat, rye, oats, and barley are harvested every year. In the crop of 1914 there was nearly 400,000,000 hundredweight of spring and winter wheat alone. Some of the best grain-raising tracts are found in the "black earth" region, the *chernoziom*. This is a band of unusually fertile land, stretching from the neighborhood of Kiev in south-western Russia in a general northeasterly direction to Tambov and the middle stretches of the Volga and somewhat beyond. It covers an area of 270,000,000 acres and, if farmed to its fullest extent, could more than feed the whole population of Europe.

To the south and east, though the climate is much drier, the grain is very good and plentiful. It was from these driest parts of the grain-producing country that Russia sent help to our State of Kansas when the continued droughts there had ruined the entire crop. The State was in a very sad predicament for a time. The situation was saved, however, by introducing the Russian grain, which had adapted itself to drought, and could therefore flourish in Kansas.

The best wheat comes from Siberia. The frozen ground thaws with the rays of the summer sun and gives to the grain a steady but just sufficient supply of moisture to produce a full, but firm wheat. Western Siberia is given up more to hay fields than to wheat fields. This is the center of the dairy industries. In 1913, 123,000,000 pounds of butter were exported—enough not only to feed Russia, but also to send to England and, in small amounts, to the United States.

To the south of the steppes of western Siberia lie Russia's Central-Asian possessions, the fourth largest cotton-producing area of the world. Since ancient times this territory has been irrigated and cotton has been raised here, though not in very great quantities. Russia used to obtain most of her cotton from China. Now the tables are somewhat turned, and many of the blue cotton coats worn by John Chinaman come from Russia. There has been a great increase in cotton growing in Central Asia and in eastern Transcaucasia; during the last decade the sowings have multiplied by three hundred and fifty times. Although over 1,300,000 acres, with a yield of over 9,250,000 hundredweight, are planted, the domestic supply is not equal to the demand, and nearly half of Russia's supply of raw cotton has still to come from abroad, from America or the British possessions.

Central Asia, particularly Turkestan, is also the original home of Russian silk. From time immemorial the raising of Bagdad cocoons and the weaving of silk, have been a staple means of support for the population. From Persia, Russia took a section of her silk-producing country when the Caucasus was conquered, and with it the province of Erivan, whose silks were famed even in the old epic tales of Russia. A great many cocoons, of the Italian variety, are raised in southern Russia. The industry, however, is quite sporadic, and it is difficult to know exactly how much is produced there. The total yield of cocoons in all three of these areas amounts to nearly 160,000 hundredweight a year. The fact that here, as usual, the domestic supply cannot meet the demand agrees strangely with the fact that Russia in 1913 exported $2,300,000 worth of cocoons, in raw silk and silk fabrics. The reason is that Russia has not yet built enough silk-winding factories. She is still dependent on foreign countries, France particularly, for fine silk fabrics and for wound silk (which is often made from Russian cocoons!)

Since the construction of the Transcaspian railroad, which opened up markets in European Russia, and consequently abroad, for the products of Russia's Central-Asian possessions, these regions have proved themselves a source of great wealth, not only because of their cotton and silk, but also because of the magnificent fruit which is being raised there in increasing quantities—luscious and fragrant apples, which turn translucent in the sun, apricots, pomegranates, figs, etc. The gardens of Central Asia are able to grow an extraordinary variety of products. Fruit culture is also increasing in the Caucasus and southern Russia; extensive orange plantations have been set out, and their fruit has become extremely popular now that the war has cut off the usual supply of oranges from Italy. Land is being reclaimed and set out in fruit farms around Astrakhan. The Crimea, with its extremely mild climate, has, of course, always been a great fruit-growing center; and Bessarabia, near the Rumanian frontier, is particularly noted for its apples and vineyards. The Russians are very fond of fruit, particularly dried, or in the form of fruit pastes or preserves, often using jam in their tea instead of sugar.

The real Russian tea, not that generally known to us and which comes to Russia from China, is being grown now in fairly large quantities. In 1913, 2,130 acres in the Caucasus, on the Black Sea coast, produced nearly 1,200,000 pounds. Russia is the only tea-growing country in Europe. The plantations, started by Chinese workers, are growing quickly and giving very satisfactory results.

Tobacco is raised either from native, American, or Turkish seeds. In 1912 there were over 175,000 acres under tobacco, in southern Russia, Siberia, and Central Asia, with an annual yield of over 2,350 hundredweight; 70 per cent of this is grown from native seeds. This tobacco is called *Makhorka*, the ordinary peasant smokes it, and it is recognized from afar because of its extremely pungent odor. American and Turkish tobacco is also raised in southern Russia and in the Caucasus.

These are but a few items in Russia's vast storehouse. She has nearly 2,000,000 acres in sugar beets, Little Russia, the southwestern region of the country, giving the highest yield and the best beet.

But she possesses one especial jewel which places her in the front rank of the wealthy nations of the world, her mineral resources—iron, oil, copper, gold, and precious stones. In the province of Ekaterinoslav, north of the Crimea and the Sea of Azov, lies the great Donetz coal basin, the largest coal field in Europe, containing about a billion tons of flame and coking coal and two and a half billion tons of anthracite. These are the best exploited of the coal mines of the Empire, because of the facilities for transportation and because of their close proximity to enormous beds of iron ore. This region, from being pastoral and agricultural, has become the "black country" of Russia. Busy industrial settlements have sprung up, and, as at Pittsburgh, the sky at night is lurid from the flames of many gigantic blast furnaces.

Then there are the great Dombrova coal fields of Poland, said to contain 855,000,000 tons; and millions of tons of inferior coal in the Moscow region. The rest of the coal deposits are still almost inaccessible. The Caucasus, for instance, is very rich in coal and is said to contain billions of tons, while the coal fields in Asiatic Russia, particularly in the province of Irkutsk, are even richer. One hundred and fifty billion tons are claimed for that one region alone. The supply in the Urals is destined to play an important part in the industrial life of the country, as soon as railroads and labor make these mines sufficiently accessible. One must always add labor to the obstacles in the way of developing the mines, because, being primarily agriculturists, the miners prefer to leave their work and go back to their farms during the harvest time, so that, while the grain is ripening and being gathered in, the amount of labor available for the mines is reduced to a low figure. Nevertheless, in time, the seventy-five billion tons of coal in European Russia and the one hundred and seventy-five billion tons of Asiatic Russia are bound to come into exploitation in the natural course of events.

This is also true of the iron resources of Russia. There are big iron centers in southern and central Russia, Poland, and the Urals. The largest deposits, and those with the purest ore, lie along the southern border of the province of Ekaterinoslav contiguous to the Donetz coal fields. This region supplies 70 per cent of the output of pig iron for European Russia, and although all the Russian ore is very easy to reduce, this ore is particularly so, and its fortunate position in regard to the coal beds nearby will probably soon make of the region one of the most important sections of Russia, and an iron famine, such as was experienced in 1913, will be made impossible. Somewhat the same happy juxtaposition of coal and iron and facilities for transportation obtain in the Altai, in western Siberia, and the temporary dearth of this valuable material will soon be overcome, and Russia will have enough and to spare.

Another of Russia's valuable natural resources is her petroleum. In this America is her successful rival. Her principal oil wells, discovered centuries ago by fire worshippers, were badly injured by having water turned into them during the revolution of 1905-1906. In 1901 the output of Russian petroleum was 50.6 per cent of the whole world's product, while the American petroleum was only 41.2 per cent. The Russian production in 1901-1905 fluctuated 10 per cent, but the American production was developing more rapidly, and Russia began to lose, so that in 1913 Russia had only 18 per cent and the United States 63 per cent of the world's output of petroleum, but the export of naphtha and naphtha products from Russia reached $24,000,000 in that year.

Russia is also rich in copper, an uncomputed wealth. In this industry America is again her more successful rival, producing 55 per cent of the world's total output, while Russia produces only 3½ per cent. Russia uses about 4,000 tons of American copper a year—after it has been metamorphosed in Germany into lamp-burners etc. Nevertheless, Russia has extensive copper ore in the Ural Mountains, the Caucasus, in the Altai Mountains, and in Siberia. In that part of the Urals which extends into the Arctic immense beds of copper have been discovered.

Zinc and lead are also among Russia's undeveloped resources; Poland, now in German hands, has the richest deposits, but the Caucasus is full of both metals. North of Vladikavkaz, on the northern slope of the mountains above Tiflis, large quantities have been discovered, and immense deposits of lead have been found in the sea coast region of the extreme east, north of Vladivostok.

The smelting industry, however, is still quite undeveloped, and the crude ore is very often shipped to European Russia or western Europe to be smelted.

Of precious metals and stones, Russia also has her share. The whole hem of her frontier towards the southeast and China is embroidered with gold, silver, platinum, and precious stones. In the Altai Mountains, part of the chain that closes in the Empire to the southwest of Lake Baikal, there are some of the largest gold mines of the world, surpassed only by those of California and the Transvaal, and all along the Lena River and the shore of the Sea of Okhotsk there are vast deposits of gold. The Urals are, perhaps, the greatest treasure house, for besides the enormous quantities of metals, base and precious, which they contain, they have a wealth of beautiful semi-precious stones, clear and colorful. In Perm, a city in the Urals, a large stone-polishing industry has been developed on account of them, and here they are transformed into the most delicious and radiant drops of color.

Then there are the fisheries, the salt works in the steppes, and an infinitude of industries, big and little, taking form, most of them being established by foreigners, for the Russian very frankly says that his industrial gift is very slight and languidly presents the samovar as the only Russian invention—an overstatement of the case perhaps, but the fact remains that for the understanding of machinery and business, he has continued to use other people's brains, so far mostly English and German. But whatever the tool Russia may choose, there is an extraordinary unanimity of belief in the greatness of her future.

Is it to come from her potential economic wealth, or from the evident genius of the Slav race? By virtue of her national landscape or from the greatness in the soul of her peasant?

To us Americans, Russia has long been an unknown quantity. Distorted expressions of her spirit have come to us from time to time, but of the conformation and content of her land we have known little and cared less. Of this one-seventh of the world's surface we have remained in almost total ignorance, but now, at last, we are trying to see the whole figure of this youngest child of Europe, both spirit and form, and we find we have many mutual bonds.

A Cheap Disinfectant

Large quantities of hypochlorite of soda are used in the laundry of a large English hospital, where it is found to be effective in destroying micro-organisms and removing stains, without appreciably injuring the fabrics. This solution is prepared on the premises by the electrolysis of a 4 per cent solution of common salt in water. With an expenditure of 10 amperes direct current at 220 volts twelve gallons of the hypochlorite solution are produced per hour, which is diluted with nine times its volume of water for use.

Rifle barrel inspection room in a government armory

Photo by Underwood & Underwood, N. Y.

Fitting stocks to rifles in a government armory

The Military Rifle

Many Delicate Operations Required to Produce a Perfect Weapon

WHILE the big guns of the artillery have taken a very prominent position in the great war the military rifle of the infantry has by no means been superseded, and the number required to equip the immense armies, and to keep them supplied is almost incredible, for, on account of injuries and losses, it is necessary to provide several rifles for every man in the ranks.

While every one of the numerous parts composing the complete rifle call for great accuracy in their manufacture, the foundation of the entire weapon is the barrel, and in its fabrication more special skill is involved than in all the other parts combined. It is therefore proposed to give here a brief sketch of the processes of barrel making, without going too deeply into technicalities.

The material generally used for rifle barrels at the present time is known as smokeless barrel steel, which, in a general way, contains from .30 to .40 per cent carbon; .50 to .80 manganese and 3.25 to 3.75 nickel. This material has been found the best for resisting the corrosive action of the gases generated by the explosion of the smokeless powder universally employed in rifle ammunition. Different manufacturers follow different methods in making rifle barrels, so in the following description only a general review of the processes will be attempted, and not a detailed account of any particular system.

In some cases the barrel material comes in the shape of rods of uniform diameter, which are cut off to the desired length, and then one end is upset, to thicken it sufficiently to form the breech; in other cases the barrels are rolled by special machinery to give them the desired tapering shape. The next process is rough straightening, for if the stock is crooked the drill which forms the bore might come out at one side. The next operation is boring, and in this the barrel is usually rotated at high speed, while a specially shaped drill is forced through the solid stock, while being lubricated and cooled by a stream of oil that is forced into the barrel at a pressure of about 450 pounds through an opening through the drill. This pressure is required to drive the chips from the drill back out of the barrel. After drilling the bore is trued up and smoothed by drawing a keen edged reamer through the bore, from one end to the other, while the barrel is being rotated as before. These operations are difficult, on account of the extreme length of the bore, and require experienced workmen to secure accurate results. After rough reaming the barrel goes through various machine operations to form the outside to the proper shape and dimensions.

Following the reaming operation, which leaves the bore of the barrel smooth and polished, comes one of the most delicate and exacting operations in gunmaking, that of straightening the interior of the barrel. This is a most necessary operation, for if the bore is not perfectly straight throughout its length accurate shooting is impossible. In straightening a barrel everything depends on the skill and experience of the operator, for although machines have been devised to perform this difficult work, they still require skilled men to operate them, and they cannot turn out as much work as is done by hand by the old method that has been practiced for years, and which can only be acquired by long experience.

The straightening block has a heavy base, on which are fixed two hardened bars of steel, set a short distance apart, and at an angle with one another. A north window is necessary, where a steady, unobstructed light is had, and the upper half of this window usually has a large pane of fine ground glass. Across this glass, at about the middle, is fixed a straightedge of wood. The operator places a barrel on a rest and looks through it at the straightedge on the window, observing the shadow cast by the edge on the polished interior of the bore. This shadow extends about half way down the bore, and if the latter is perfectly straight, the shadow shows two straight dark lines, one on either side of the bore and slightly below its center. If, however, there is a crook in the bore the lines of the shadow diverge from a straight line, and zigzag in various directions as the operator revolves the barrel by hand; this indicates that there are crooks in the barrel. To correctly observe these delicate indications requires unusually perfect sight, and to locate the point and nature of the crook is a matter of long experience and judgment. When the operator has located a crook, he lays the barrel across the bars of his straightening block, with the high point of the curve uppermost, and strikes it with a heavy hammer made of copper or babbit metal, and great judgement is necessary to know just how hard to strike to remove the crook. This process of observation and straightening is repeated until the two shadow lines are perfectly true for one half of the length of the barrel, and then is repeated for the other half, observations being taken from the opposite end. The difficulties of straightening depend on the size of the bore and the material, increasing as the bore is smaller and the material harder. Besides errors in straightness there are other defects resulting from imperfect boring and reaming that are discovered at the same time; and many of these can be remedied by the above methods.

Another method of straightening sometimes practiced is by placing in the muzzle of the gun a lens covered with cement, in which a circle is scratched. On looking through the barrel with a suitable light a series of rings appears in the bore, and the slightest lack of concentricity of these rings indicates a defect. This is said to be an extremely delicate test.

After straightening the barrel is ground on a grindstone to smooth the exterior, and remove all tool marks; and is then again reamed to bring the bore to its finished size. Then follows a careful gaging to determine if the bore of the barrel is true to the required size; and following this it is leaded—that is, a lead bullet is pushed slowly through the barrel by hand with a brass rod. If the bullet, which fits the bore snugly, meets with any obstruction on its passage through the bore the barrel is sent back for correction or rejected.

The next operation consists in rifling, or cutting the grooves in the bore that engage the bullet and give it the rapid rotating motion when fired that is necessary to make it follow a straight course. There are from four to seven of these grooves, cut spirally, and with a twist of usually one turn in ten inches for a barrel 24 to 25 inches long.

In an intermediate operation the barrel is rolled on a smooth surface to ascertain if it is straight on the outside for if not the sighting would be interfered with, and straight shooting could not be done, even if the bore were perfect.

The barrel is now smoothed on the outside on polishing wheels, and then "browned." The operation is called browning, although the final color is dark blue, because it is first subjected to a chemical bath that forms a coat of rust in the outside. This is followed by a second bath, after which the barrel is finished on a wire card wheel. This process is repeated until every bore is thoroughly covered by a coating that offers a very efficient protection against rust in ordinary use.

There are a number of other operations on the barrel, such as chambering for the cartridge and fitting the sights, but these are technical operations requiring no particular description.

All military rifle barrels are subjected to a high powder test before, and a target test after, rifling. The first test varies according to the grade of steel in the barrel, high nickel steel barrels being tested with a powder charge which would burst a low-grade steel barrel. The test charge includes a heavy leaden slug, and the combination is from two to three times as heavy as the charge which would ordinarily be used in service. Should there be seams in the stock or other defects, the first test preceding the test after rifling, which is made with the regulation charge in order to determine the accuracy of the rifle, will bring them to light.

The facts contained in the above description are derived mostly from a series of excellent articles that have appeared in *Machinery*, in which the matter of rifle construction is gone into very thoroughly, and in considerable detail.

Formation of Albumin by Yeast From Different Sources

IN the large-scale production of yeast the carbon nutriment is the most difficult problem. Although urea can serve as a source of nitrogen, its carbon is not assimilated by yeast. According to the investigations of Naegeli and others, organic acids (citric, acetic, tartaric), as well as glycerol, asparagine, peptone, mannitol, and other carbohydrates, can be used as sources of carbon for yeast, and the nature of the latter determines the utility of the different sources. Pentoses are unfermentable, but, in suitable circumstances, can serve as sources of carbon. Dextrins are scarcely fermented by yeast cultures, but readily by crude yeast. Alcohol is utilized as a source of carbon by many moulds and bacteria. The growth of many yeasts is more vigorous in solutions containing alcohol than in sugar solutions. Brewers' yeast requires the presence of sugar during cultivation because the fermentation is a protection against bacteria. The development of other moulds is checked by the rapid formation of alcohol. Attempts to replace a portion of the sugar by methyl alcohol were unsuccessful, but good results were obtained with glycerol.—Note in *Jour. Soc. Chem. Ind.* on an article by T. BOKORNY, in *Münch. Med. Woch.*

The History of Individual Armor*

Their Evolution Since Antiquity—Their Future

The history of the transformation of defensive arms is closely connected with that of offensive arms. For this reason it is legitimate to distinguish two periods of their evolution, as follows:

1. Period of side arms associated with low power projectile arms (bow, cross-bow, javelin).

2. Period of fire-arms.

The common limit of these two periods corresponds with the end of the fifteenth century or the beginning of the sixteenth century, and their characteristics are: for the first, the progressive evolution of the individual system of defense, and for the second the regressive evolution of the same system which declined in a course parallel to the perfecting of the fire-arm.

I. *Period of the Steel Arm.*—The remains of prehistoric human industry principally inform as to the offensive weapons of our ancestors; but tell us little or nothing of their weapons of defense. It is not necessary to conclude thereform that this system was then non-existant, and it is probable that this part of the armament, whether of huntsman or warrior, formed a portion of the clothing itself. In any case it can not be considered as absolutely improbable that besides the protection afforded by thick garments of skins or furs, a man should seek to protect himself by the aid of a buckler, which, in the chronological evolution of arms, would thus be obviously contemporaneous with the axe and the arrow.

Next to the buckler or shield, the helmet and the cuirass hold the place of importance in the protection of the combatant, but their origin is less remote from our own times. In the Celto-Slavic group, in the regions of the North and the West (IXth to IIId century B. C.), we find however, the head-piece of bronze, and dating from the Gaulois epoch, bucklers of wood or reïnforced with bronze or iron. In the basin of the Mediterranean warriors have made the same use of these arms since the dawn of history; the cuirass, (*thorax* among the Greeks, *lorica* among the Romans) is completed by a system of plates designed to protect the limbs. This high degree of perfection, however, was not able to survive the fall of the Roman Empire in the Mediterranean basin, and it left behind it only examples quite embryomic in execution. Thus, among the Franks, the defensive element was represented only by the association of buckler and helmet without cuirass, and when the latter reappeared later (epoch of Charlemagne, IXth century), it is under the form of a waistcoat made of overlapping metal scales, and of imperfect execution. A handsome model of this piece of armor is to be found in the Army Museum at the Invalides. In this same reconstitution we remark a helmet with a high crest completed by a head-protector and a leather gorget.

In the XIth century the Bayeux tapestry shows us, as also the seal of Richard Coeur-de-Lion, the coat of mail assuming first the shape of a redingote, then that of a bathing suit; completed by a helmet conical at the nose it constituted the equipment of the Norman warrior, whose feet and hands were protected by plates of leather.

In the XIIth century the sculptures of the Rheims Cathedral as well as the evangeliarium of St. Louis (National Library) show a perfected coat of mail, a metal combination united with the helmet by a passemontagne of steel link; the ensemble, constituting the *heaubert* protects the warrior with the *heaume*, a cylindrical helmet made of pieces of forged metal, adjusted by rivets and pierced by two peep-holes.

At the beginning of the XIVth century the desire to protect the joints caused the placing of metal plates at shoulder and knee to cover these articulations. The *heaume* has disappeared, and is replaced by a helmet of the type called *bassinet* with a movable visor pierced by holes to permit sight and ventilation.

Not long after (middle of XIVth century) we remark the rapid introduction of true armor, which thus took the place of chain armor. The plates at the joints were extended to the interarticular portions, at times in both direction, longitudinal and circular, in such a manner as to enclose the limb in a metal *greaves*; the hand is protected by an articulated gauntlet, and the foot by an iron shoe the *solleret*; the body was still covered by a shortened coat, of the length of a waistcoat (veston), the *haubergeon*. This ensemble constitutes a *harness*, to which we soon see added the steel corselet which is prolonged over the abdomen by a sort of skirt of interwoven metallic rings, the *tasselles*. The complete cuirass appears finally in the reign of Charles VII, augmented by new pieces, the shoulder pieces and the gorget, which unites the armor to the round helmet. Thenceforward the knight is enclosed in an exceedingly heavy carapace (80 kg.) which renders him almost invulnerable. Thus, weighted and awkward of movement, he can neither mount his horse nor dismount without aid; dismounted he is at the foe's mercy; therefore to diminish the chance of his being dismounted, the man's defense is completed by armor for his horse, the first specimens of which appear in the reign of Charles VII.

The man on foot is far from being as well protected; bearing arms of offense for throwing projectiles which

The protection of a modern soldier

make necessary great liberty of motion, he has no such need of being enclosed as has the cavalier, and is therefore protected only by a helmet, shoulder-pieces, shield, arm and thigh pieces, knee pieces and a short coat of mail or haubergeon, to which is added in certain circumstances, an abdominal demi-cuirass. The Franc archer of the time of Charles VII displays admirably the maximum development of defensive armor for the foot-soldier.

II. *Period of Fire-arms.*—Suddenly, in the course of a few years, we behold armor greatly simplified—a result, in fact of the use of gun-powder, which in the space of some ten years made useless what had been the patient acquisition of centuries. The reorganization and improvement which artillery underwent at the hands of the *Frères Bureau* (reign of Charles VII) gave it the mobility required for playing an important rôle. The appearance on fields of battle of long movable guns borne by carts, the so-called flying engines, somewhat changed the conditions of defensive armament, less, however, than those of the weapons carried by hand, culverin in particular, which were used in the battle of Morat (2d half of XVth century) and determined the victory of the Swiss over Charles the Bold.

The smaller fire-arms at first were very inferior in respect of range and rapidity of fire to the older projectile throwers operated by hand; however, the improvements it underwent rapidly endowed it with a factor of the utmost importance in its direction of increased energy and power of penetration. As early as the beginning of the sixteenth century projectiles had become capable of piercing the armor of the times and artillery, having become easier to handle, often decided the fate of battles.

The intervention of fire-arms, therefore, changed the methods of combat, which, though still individual, became anonymous; fighting was from a distance, without knowledge of the origin of the blow; the benefit of protection was thus considerably lessened and quite naturally the combatant sought security in mobility and rapidity of maneuver. The lightening of the soldiers' burden, of both horseman and foot soldier, therefore, was necessary, and rapidly increased, immediately after the important reform by Gaspard de Coligny (middle of XVIth century). The pistolet introduced into the armament of the cavalier in the regins of Francis I and Henry II, was completed by the arquebus, and finally, the arrival among the French troops of numerous German horse-soldiers mostly making use of fire-arms, obliged in 1570, the noble French cavalry to abandon the lance and reduce armor in favor of a lighter equipment.

The causes of the regressive evolution of defensive armor is manifested more and more strikingly, progressing with giant strides, tempered only by a desire to preserve a certain measure of protection against the side arm which had recovered some of its importance since the invention of the bayonet (Spain, 1660). This regressive evolution is marked by the following stages: First the buckler disappeared at the same time as the metal plates for protecting the limbs; the helmet and the cuirass, however, persisted for a long time; the former disappared during the reign of Louis XIII, and the cuirass was finally sacrified in its turn during the reign of Louis XIV.[1] A timid attempt at the revival of the helmet was made under Louis XV, when the dragoons were created, and the cuirass was re-established together with the helmet among the cuirassiers in the last years of the Revolution; but it is a particularly remarkable fact that there was a tendency to substitute for the protection of metal against side arms of thick layers of fabric. This idea gave birth to the epaulet, the *crimière* or horse-tail plume, the shako and the bearskin cap. These gifts of the empire remained the basis of military equipment in France during almost the whole of the nineteenth century. But with modern wars a new idea sprung up: individual protection by means of invisibility and dispersal of the units. From this doctrine are born theservice uniform and the methods of utilizing of the terrain in dispersed order, methods which apply to units of every degree of importance.

But if this ensemble of conditions meets failry well those of combat at great distances such as that practiced in the war of movement, it is quite otherwise in stationary fighting or trench-war like that of today; and this brings us to the consideration of the system of individual protection in the present war.

III. *Present War.*—Besides the collective system of protection, which consists in the fortification of the country, a tendency has been manifested among the belligerents to adopt methods of individual protection. This tendency is exhibited in the use made of masks and spectacles as protection against asphyxiating and tear-producing gases, and above all in that of the helmet which is constantly worn by the soldier on the firing-line or which is donned only during a bombardment or attack.

The idea of adopting helmets has been latent for a long time. But it was only the growing frequency of cranial wounds by low speed projectiles that led to the decision in the first half of 1915 to take steps in this direction by the adoption of the *cervelière* or metal cap worn under the képi.[2] The success of this among the soldiers was poor; they recognized the efficacy of the *calotte* but accused it of causing headaches; also, with few exceptions they employed it for a variety of uses for which it was not designed; turn by turn it served for a cup, a cooking utensil, (especially for preparing coffee), and finally, the irony of fate, as a urinal.

Its efficacy, however, was undoubted.

In a communication to the Academy of Medecine in 1915, Professor Le Dentu and Dr. Devraigne demonstrated with the assistance of figures the incontestable

*Translated for the Scientific American from *La Nature*.

[1]Except for the engineers, who were in the trenches—and continued to wear till the siege of Sebastopol—the cuirass and special sort of helmet, the "head-pot."

[2]In the 10 years prior to the war, not only the helmet had been contemplated, but also a portable shield for the infantry.

utility of the cervelière[3]. They cited notably the instance of numerous calottes which were dented or broken without the wearer being wounded.

The proofs were such that the present helmet was adopted; its characteristics have already been frequently described. The results were remarkable, and from its coming into use at the end of August, 1915, the soldiers showed themselves to be greatly pleased; in the attacks of September, 1915, many were the soldiers who were saved by their helmets. In a communication to the Academy of Medicine, March 7, 1916, Chief Surgeon Roussy demonstrated its value by a comparative examination of the figures of wounds of the cranium observed in service. He remarked that the percentage of wounds rose after the adoption of the helmet; this fact, apparently unfavorable, in reality signifies the high value of the protection. For the fact is that the number of wounded was augmented because the number of killed was decreased.

Let us quote a few of the facts at random: Professor Souques (Society of Neurology, Nov. 9, 1916,) exhibited a soldier whose helmet was considerably broken by fragments of a shell, the bearer suffering only from a scalp-wound and cerebral shock.

Two of the many instances published are particularly instructive, one reported by Drs. Broquet and Roulland, and the other by Chief Surgeon Roussy. The first concerns a traumatism occasioned by a ball fired at a distance of 1,800 meters and arriving with full force at an angle of 50 degrees, so that without a helmet the projectile would have penetrated the cranium; instead of that the ball was deflected and stopped without causing a wound. The second case, still more remarkable, concerns a soldier whose helmet was struck in the frontal region, under an angle of 45 degrees, by a rifle ball fired at 200 meters and arriving with full force. This would have been a mortal wound, but thanks to the helmet, the ball was deflected outwardly and was finally arrested between the hair and the metal. The injury of the wearer was confined to a contused scalp wound.

The instances are legion which demonstrate the resistance of the helmet to projectiles arriving obliquely thus assuring a sufficient average protection; in any case the practical conclusion from this study of the helmet is that even when very thin (and light) it considerably improves the statistics of cranial wounds, both as to frequency and as to gravity. This conclusion is not applicable merely to head wounds, the principle should be extended to other dangerous regions of the human body. Figures are worth more than phrases to prove the reasons why.

From a very interesting book recently published,[4] are extracted the following figures concerning projectiles, derived from 479 observations of abdominal wounds followed by immediate or early laparotomy: Shell fragments (low energy), 332 cas. Balls (high energy), 147 cas. It may be objected that this manner of summing up the projectiles forms an arbitrary distinction; but if any error is thereby committed it is one considerably to the advantage of the high-speed projectiles to the detriment of the other catagory. In fact, among the balls have been counted shrapnel (low-speed) and rifle balls; among these latter the balls having high-speed are naturally eliminated since, as we have said, the figures quoted concern cases of wounded men operated upon;[5] but it is well-known that at short distances high speed projectiles produce, at the plane of organic cavities, explosive effects which are immediately mortal, just as projectiles, important because of the large volume of the mass, killed by the extent and width of the wound. To resume, it is obvious, therefore, that after more ample examination, the catagory of projectiles of low energy $\frac{mv^2}{2}$ is increased rather than diminished.

As regards wounds of the thorax, the figures obtained by summing up the wounded of the same category, on the same dates, are as follows: The same ambulance at the front, in a series of recent date amounting to 15 wounds of lung penetration, counted: Shells, 10; shrapnel, 1; grenade, 1; doubtful, 2; balls, 1.

Of these 15 wounds only two had two orifices, *i.e.*, seemed to be perforating, all the others relate to projectiles retained in the thorax (therefore of low energy). Though but few conclusions can be based on statistics obtained by summing up the foreign bodies extracted secondarily, there is some reason to consider them, since they show with what frequency balls at the end of their flight, with only a very low energy, lodge in the lungs.

In 72 observations of projectiles extracted from the lungs (in cases of men wounded between August, 1914, and May, 1915, we find: Balls, 33; shrapnell, 11; shells, 26; grenades, 2. That is 33 bullets against 39 explosives and shrapnel. And the very small fragments were not extracted! And the rifle and the machine-gun played a more important rôle at the beginning of the war!

Contrary to the effects produced at the plane of the abdomen, the projectiles retained in the thorax are especially dangerous because of the infection they carry with them and which develops about the foreign body. Dr. Schmid (of Nice) established the fact that in wounds of the chest observed by him, the mortality rose to 4.5 per cent for balls, and to 40 per cent, or ten times as many for shell-fragments; and since among these latter in five cases of shell-fragments retained, there were four deaths from infection the importance of this is seen as a cause of decease.

Articular wounds lead to the same conclusions. Statistics obtained by uniting 69 observations published by the same ambulance at the front, following the combats of October, 1916, give the following figures: Shell fragments, 48; grenades or bombs, 13; rifle bullets, 4; shrapnel balls, 2; revolver bullets, 3; *torpilles* 1; doubtful, 1. That is 66 wounds from projectiles of low-energy against five bullets.

These statistics comprise only penetrant wounds, *i.e.*, foreign bodies of very low energy are not even included. But in the total number of wounds, 55, or 79.6 per cent were from projectiles retained, and 13, or 18 per cent were perforating. Hence, the proportion was as follows: Shells, 42; grenades, 12; *torpilles*, 1; revolver, 1; rifle, 0. Perforating projectiles: Shells, 5; rifle, 4; grenade, 1; doubtful, 1.

In the face of these statistics it is hardly necessary to add that the gravity of articular wounds is principally connected with the retention of foreign bodies in the wound; yet this helps us to comprehend the importance of protection from projectiles of average energy. With respect to wounds of the eye-balls (entailing the loss of the injured eye), the statistics of Dr. Lapersonne and Dr. Terson show that in 4/5 of the cases the wound is caused by a projectile of small size and minimum energy, and therefore avoidable.

To resume, we may derive from the preceding the five conclusions which follow: 1. Projectiles of average energy (shell-fragments and shrapnel) are the most frequent cause of wounds in the present combats, (3/4, if not more, of the total). The bullet, (of rifle or machine gun), frequent at the beginning of the war, has become of much less importance.

2. The small projectiles of low energy are very often the determining cause of mortality or invalidism.

3. Numbers of projectiles are easily arrested by a thin metal plate: the adoption of the helmet has shown the importance of protection.

4. Only the average statistics (of killed and wounded) should be taken into account.

Like everything else the system of protection has its dangers and inconveniences; but if we abandon it we must be logical, and give up other measures of protection, such as trench digging, shelter building, etc.

Trench war has created new conditions; hence we must break with the measures for lightening weight demanded by the war of movement and take those which the former imposes. Let us think, above all of avoiding death or invalidism for our soldiers.

[3]Among 105 killed and wounded there were 14 wounds of the head, or 13.3 per cent. In a total of 55 cranical wounds 42 were of those not wearing the *calotte*, or 26.3 per cent. From the point of view of gravity among the 42 wounded not wearing the *calotte* were 23 fractures (or 60 per cent, with many deaths consequent) and 19 scalp wounds, while of 13 wearing the *calotte* there was no fracture, no death, only 8 cerebral shocks, and 5 superficial wounds.

[4]Dr. Abadie (d'Oran). Wounds of the Abdomen. Horizon, Masson & Co., 1916.

[5]In hopeless cases the wounded are dead before the arrival of ambulance.

The Markings of Mars*

Alfred Rordame

A NUMBER of astronomical writers, in describing the markings of the planet Mars, treat the subject as though writing up an irrigation project in our own arid region. In writing glibly about this canal and that, these authors make no distinction between mere imaginary names and actual truth. The consequence is that the young and inexperienced observer, who would like to see with his own eyes the marvels that others claim to see, is disappointed and blames his telescope, eye, or the air at his station.

The fact that only a limited number of people are enabled to see the markings of Mars as straight lines intersecting one another in a geometric network, and the fact that observers with giant telescopes have failed to confirm the startling hairnet effect seen with smaller instruments, should at least make us skeptical as regards the actual form of the markings. The observers who draw canals on Mars apparently use a straightedge, treating the surface of the planet as a flat disk instead of a globe, as we know it is. This is no exaggeration on my part, for Professor Schiaparelli defines the "most perfect" type of canal as "a dark line (sometimes quite black), well defined, as it were drawn with the pen on the yellow surface of the planet." In this connection it might be interesting to quote a remark made by Dr. Lewis Swift to Captain Noble: "Let me look," said Swift, "at Schiaparelli's map with a bright light for a while and then go to the telescope previously adjusted on Mars, and I see the canals just as marked on his map. After reading my circles a certain length of time with a bright light and then go to the telescope, I see the graduations on the sky, and they last for some little time. It has occurred to me that some or all of the canals seen by many may be caused in the same way."

E. M. Antoniadi, F. R. A. S., one of the most experienced of modern observers, states that "under no circumstances whatever can I keep a Martian canal steadily before me. At best, the canals appear to me invariably by glimpses only, every glimpse rarely lasting more than a small fraction of a second. Rev. T. E. R. Phillips, F. R. A. S., states: "Faint markings have been glimpsed now and then, and it would be easy, by the scientific use of the imagination, to conjure them into lines and streaks harmonizing with Schiaparelli's charts."

Thus we see from these quotations that, notwithstanding Prof. W. H. Pickering's dictum that the canals are easily visible in his 3-inch finder, in reality they are seen with the greatest difficulty in telescopes of 9½-inch aperture. Personally, observing with telescopes, both refracting and reflecting of from 4¼-inches to 16 inches, I have never been able to see these markings excepting as boundaries of areas of different albedos. This also bears out the statement of N. E. Green, F. R. A. S., whose drawings of Mars have never been surpassed: "I have been deceived sometimes by the edges of faint tones, and have drawn them with a single line, only to find out my mistake when the form came to the meridian, and its whole shape was made evident."

Of the real nature of the markings termed canals, I maintain that we still know very little, though the explanation quoted below, and which was put forward some years ago by Maunder, is deserving of consideration: "Experiments made some years ago on the limit of sight, without optical aid for small objects, demonstrate that whereas the smallest dot that one can clearly see with the eye must subtend an angle of about forty seconds, I was perfectly conscious of the existence of a line when it only had a breadth of about eight seconds. At the same time it could not be called distinct vision; I was conscious of the line, but it was not sharply defined on the eye. The reason, I suppose, was that the dot simply affected one element of the retina, 40 seconds being about the diameter of the rods of the retina, whilst the line passed over a number of them, and so produced a certain indistinct but appreciable effect. It seems to me, therefore, that if we have on a planet or any celestial object a number of small markings, each of them individually below the limit of distinct vision, we might very easily get the effect of narrow straight lines, and from the beginning of the controversy as to the canals of Mars it has seemed to me that a good many of them probably owe their existence to something of the sort. The observers are really trying to form a distinct impression from the confused result of an aggregate of *minute* markings, each of which is individually beyond the power of the eye to grasp."

Professor Barnard when at the Lick Observatory in the early nineties devoted a great deal of his time to the observation of Mars with the 36-inch refractor, and has the following to say of the more permanent dusky markings variously called seas, marsh, etc., and supposed to be areas of permanent vegetation: "Under the best conditions these dark regions, which are always shown with smaller telescopes of nearly uniform shade, broke up into a vast amount of very fine details. I hardly know how to describe the appearance of these 'seas' under these conditions. To those, however, who have looked down upon a mountainous country from a considerable elevation, perhaps some conception of the appearance presented by these dark regions may be had. From what I know of the appearance of the country about Mount Hamilton, as seen from the observatory, I can imagine that, as viewed from a very great elevation, this region, broken by canyon and slope and ridge, would look just like the surface of these Martian 'seas.'"

*From *Popular Astronomy*.

Fastening Metals to Marble

A MOST useful cement for fastening metal parts to marble, as in the case of an electrical switchboard, is formulated in the *American Machinist*. It consists of thirty parts plaster of paris, ten parts of iron filings and half a part of sal-ammoniac. These materials are intimately mixed and then acetic acid is added to make a thin paste, which must be used immediately after mixing.

Galvanizing and Tinning Iron Wire

The enormous consumption of barbed wire, generally galvanized, incident to trench warfare, lends special interest to an article on the latest processes of galvanizing contributed to *Stahl und Eisen* by Mr. Altpeter. Since no German periodicals have reached this country for several months, we take the following abstract from *Le Génie Civil:*

Galvanizing.—The author describes in especial the two processes most employed for galvanizing or zinc coating, dipping in a bath of melted zinc at 450° C. (the point of fusion of zinc is 420° C.), and the passage through a cold electrolytic bath. The zinc used for galvanizing by heat is generally 98 per cent pure; its impurities consist of lead (from 0.66 to 2.55 per cent), iron (from 0.02 to 0.26 per cent), cadmium (from 0.02 to 0.09 per cent), and tin (from 0.03 to 0.07 per cent). Mr. Altpeter protests against the requirement of consumers who demand that galvanized iron exposed constantly to inclement weather should be entirely and indefinitely inalterable. He shows that its protection is necessarily limited however well the process of galvanization is conducted, and however pure the protective layer of zinc. The attack is due to the formation of a zinc-iron couple; it is progressive from the time it begins. Doubtless less impure zinc, deposited by electrolysis, is almost non-attackable by dilute chemical and atmospheric reagents; but, since the layer of zinc is very thin (a thick layer thus deposited would be very slightly adherent, as well as porous and brittle), the iron underneath is easily scraped bare by the accidental manipulation incident to its use. This is particularly the case with barbed wire.

Contrary to what migth be supposed, the zinc layer deposited by electrolysis on iron wire is not chemically pure: part of the impurities of the zinc employed as the anode are deposited upon the wire. In galvanizing by dipping in molten metal, not only does the total amount of these impurities pass into the protective layer, but so does "hard zinc," an alloy of zinc and iron which will be spoken of later. Because of the thinness of the protective coating, in spite of a little greater purity of the zinc, the iron wire galvanized by electrolysis, is therefore not much less alterable than the other. The electrolytic process is of advantage only to the manufacturer; the expenses of installation and of exploitation are less, the consumption of zinc for a given quantity of wire is less, and finally, a part of the metals comprised in the impurities of the zinc forming the anode are recoverable in an easily utilizable form.

Before being galvanized the wire must be cleansed. For the purpose a bath of hydrochloric acid is generally employed, sometimes of sulphuric acid, very dilute and quite free from arsenic, for an acid too concentrated prevents the adherence of the zinc coating, and the least trace of arsenic causes black spots.

Before entering the bath of melted zinc the cleansed wire is rinsed and brushed, and then, in some factories, passed through a solution of zinc chloride, when it is desired to increase the adhesion of the protective coating. At the point where the iron enters the melted zinc the suface of the bath is covered with sal ammoniac. Of late a double chloride of zinc and ammonium has been preferred, as less volatile and more efficacious than sal ammoniac. To improve the color of the zinc coating aluminum is added (0.1 per cent of the zinc, never more than 0.25 per cent) or bismuth, to the dipping bath. The aluminum can not be introduced except in the form of an alloy with the zinc. Aluminum has, as is well-known, a highly favorable de-oxidizing action, but it tends also to diminish the quantity of hard zinc formed; it renders the bath more fluid, and consequently the galvanizing can be done at a lower temperature, a condition favorable, as is stated farther on, to the diminution of the quantity of hard zinc formed.

Mr. Altpeter describes in detail the various operations in hot galvanizing, insisting upon the means of achieving the following objects: 1. Obtaining galvanized wire which is very lustrous and less alterable. 2. Avoiding the formation of an excess amount of hard zinc. 3. Avoiding the formation of excessive quantities of dross, rich in metallic zinc and in zinc oxide, resulting from the slow action of atmospheric oxygen at a high temperature.

Hard zinc is an alloy of iron ($Fe\ Zn^3$ and $Fe\ Zn^7$) which results from the slow dissolving of iron in melted zinc. This iron comes from the objects being galvanized and from the tank which contains the melted zinc. It collects in rather hard and adherent layers, more or less thick, on the bottom and sides of the tank. This hard zinc must be frequently removed, for if the wire to be galvanized traverses it the protective coating will be dull, granular and only slightly adherent, and with a tendency to scale. We can somewhat diminish the formation of hard zinc having its origin in the tank, in two ways: We can smear the sides with a paste made of clay and water glass (silicate of soda) which is allowed to dry; and we can protect the bottom by means of a layer of melted lead, which, being denser than the zinc, remains at the bottom and has no tendency to combine with the iron. Moreover any hard zinc which may be formed, being also less dense than the lead, will float upon the lead and can be removed with ease. While it is true that zinc combines with lead it is only in insignificant quantities under the present conditions of operation. The best means of lessening the formation of hard zinc is to increase the dimensions of the galvanizing tank, so that the metallic mass being very considerable, will act as an accumulator of heat and prevent a notable elevation of the temperature.

This tank, made generally of plates of cast steel 15 to 30 millimeters thick, carefully joined with autogenous welding, has a capacity which varies from 4 to 20 cubic meters.

With a tank made of steel very poor in phosphorous and in silicon, the dissolving of the iron in the zinc can be avoided, provided the temperature of the bath does not exceed 490° C. The most favorable temperature for hot galvanizating lies between 440° and 480° C. The variations of temperature of the bath should be followed with a continuous indicating pyrometer. As soon as the temperature seems to be rising steadily and about to reach a dangerous height, the activity of the firing is lessened.

The regulation of the temperature is much facilitated if in place of the ordinary furnace we make use of one fed by a gas generater.

The lost zinc, in the form of hard zinc or dross is of little value except for the manufacture of zinc white; it often represents as much as 50 per cent of the zinc actually deposited on the iron wire, and at times much more.

On issuing from the bath the wire is freed from excess of zinc by passing into an apparatus where it is compressed between cylinders or plates covered with asbestos. The same result is attained in some plants by surmounting the bath of melted zinc with a layer of moist, sharp sand, 10 to 12 centimeters in thickness.

The processes of hot galvanizing by means of zinc gray, or powdered zinc (metallic zinc in the state of powder resulting from the first condensation during the manufacture of zinc by the process of Sherard Cowper-Coles [Sherardizing] and the Schoop process of pulverization) are very briefly described by Mr. Altpeter.[1] Sherardizing, however, is suitable only for small objects whose three dimensions are nearly equal: bolts, balls, locks, disks, screws.

The Schoop process is peculiarly suited to objects of large size. Galvanizating by electrolysis, on the contrary, is described in detail by Mr. Altpeter; however, the article is lacking in one essential piece of information, the composition of the electrolyte; the author says only that it is acid. Its composition is kept secret and furnished only to the exploiter by the constructor, a German house, and only after a definite order has been given.

All the processes of galvanizing iron wire follow a continuous series, the wire unwinding from one reel, passing into the various baths where it undergoes the operations indicated, and rewinding on a second reel. In this way 50 wires at a time can be galvanized, placed parallel in the various baths.

The metallographic methods for determining by what process the iron has been galvanized are set forth by Mr. Altpeter; they offer nothing of special interest.

Very simple tests permit the determination with sufficient speed and accuracy of the probable durability a galvanized wire exposed to the weather, and of its resistance to wear. These tests take account at once of the resistance of the protective layer to chemical reagents and of its resistance to breaking, to cracking and to scaling under the effect of torsion or of repeated bending.

Here are the tests in use by the administration of the German posts: The wire is immersed in a solution containing 20 per cent of copper sulphate, kept at a temperature of 15° C., for one minute, and this immersion is repeated until the wire is covered with a continuous and adherent coating of copper. The number of immersions forms a measure of the resistance to atmospheric and chemical reagents. The minimum number of immersions exacted by the contract varies with the diameter of the wire; the idea, in fact, is, that at the moment when the wire issues from the bath continuously, the coarser the wire the thicker the coating of melted zinc retained.

To measure the resistance to scaling and to surface crack the galvanized wire is wound in close spirals upon a cylinder whose diameter is ten times that of the wire. Examination under a magnifying glass of a sample thus obtained should reveal no fissures, nor any particle detached from the coating. This test is not convincing unless the thickness of the coating does not exceed a certain limit; for if it is very thick, like that easily obtained by hot galvanization, it has no tendency to scale.

Covering iron wire with tin or lead.—The two processes of tinning by heat and by electrolysis form the subject of a very short description; it is the same with the process which enables us to cover the iron with a coating of lead. In the latter case, we operate always with heat, by immersion in a bath of melted lead at about 350° C., after having previously galvanized the object to be protected. The adhesion of the lead to the zinc is complete, for these two metals combine with each other with facility. We can still further facilitate this combination by two methods: 1. By causing the already galvanized wire to traverse a melted layer made either of zinc chloride; or, better still, a mixture of zinc chloride and ammonium chloride. 2. By adding to the bath of melted lead 0.17 per cent to 1 per cent of cadmium and 0.5 per cent of zinc.

The tinned and the leaded wire alter much less quickly when exposed only to the weather, than wire simply galvanized. Both tin and lead being less hard than zinc, the tinning and leading are not recommended when the object to be protected is subject to friction.

[1]For the first process see the *Génie Civil* of Oct. 1, 1910 (vol. lvii, No. 22, p. 414); for the second, *Génie Civil* of June 24, 1911 (vol. lix, No. 8, p. 170), and Dec. 21, 1912 (vol. lxii, No. 8, p. 154).

On the Greater Use of Indian Foods

The war that is upon us will sooner or later compel us to conserve to the last degree our economic strength by the elimination of actual waste in food and by the higher and more scientific use of the materials at hand. Food habits are notoriously fixed, but great events sweep away prejudices. We have inherited most of our food habits from the Old World and we call wheat bread "the staff of life," even though the same nourishment can easily be secured in other foods. Now maize is the great aboriginal food of America and its possibilities have been imperfectly realized by ourselves. This grain is just as much a favorite staple among our neighbors in Central America as is rice among the peoples of southern Asia or wheat in western Europe.

Certain dishes of the American Indians were adopted by the early colonists in New England and elsewhere. Thus, samp was instantly appreciated by the hungry English and described by Roger Williams in 1643 as "Indian corn beaten and boiled and eaten hot or cold with milk or butter." At a still earlier date, 1630, Captain John Smith mentions hominy, a name ordinarily applied to maize that has been boiled with alkali. The alkali (lime, potash, snails' shells, etc.) causes the outer skin of the grain to peel away, leaving the white inner portion soft and palatable. This method of preparing maize was widespread over North and Central America. Succotash is a Narragansett word that has been misapplied to a mixture of corn and beans; it originally meant simply an ear of maize. Hoe cake was taken over from the southern Indians. A favorite food of the early explorers and trappers was parched corn meal, which combines great nourishing power with slight weight. This was much used by the Iroquois warriors in their long raids against other tribes, when each man had to carry his own food.

But the Indian tribes of our Southwest and of Mexico and Central America are more civilized than those from whom these foods have been adopted, and their culinary efforts are more worthy of imitation. A greater use is made by them of maize flour in contradistinction to rough meal. The "paper bread" of the Pueblo Indians is gruel baked on stone stoves. The top of the stove is smoothed by an addition of clay and oiled with pumpkin seeds. This "paper bread" may be of several colors, according to the different kinds of maize, and it has excellent keeping qualities. In Mexico the same method is employed for *totopozli*, which is, however, baked until brown and crisp.

Hulled corn or hominy, ground into a paste, furnishes dough for the *tortillas* or unleavened cakes that take the place of bread in Mexico. Although the ordinary *tortilla* is rather soggy, when made thin it is delicious. For a breakfast dish nothing can surpass the *enchilada*, which is a *tortilla* rolled up cigar-fashion with a little meat, cheese, or chili pepper as a surprise in the center. This is toasted before the fire until it is crisp and crackling. *Pinole* is, properly speaking, a parched meal made from maize and other seeds. The word is applied to a variety of dishes, such as stews of maize, meat, and chili peppers. *Pinolatl* (*pinole* water) and *posole* are refreshing drinks made by stirring maize paste or dough into sweetened water. The *tamale* is perhaps the best known dish of the Mexican Indians, at least as far as the word is concerned. It is made in many different fashions. —Herbert J. Spinden in *The American Museum Journal*, published by The American Museum of Natural History, New York.

Photo by American Museum of Natural History, N. Y.

Unusual food materials exhibited at the American Museum of Natural History, New York. At the upper left is dulse; center, a squid; right, mussels; middle of picture, periwinkles; right, sand collar snail; foreground, kelp

An Era of New Food Resources

With the steady dwindling of the regular food supplies of the world, governments and scientific men everywhere are ransacking the uttermost corners of the earth, as well as the depths of the sea for new materials suitable for human consumption to make up for the serious shortage that is threatened. This is really by no means a new movement, for our Government departments, together with many institutions, have been working along these lines for many years, and many new sources of food have been developed, especially among the fishes. Now however, the search is being prosecuted with renewed intensity, and many things are being suggested that were never thought of before.

Our illustrations show portions of some exhibits prepared by the American Museum of Natural History, in New York, for the information and education of the public. Some of these are not entirely new, although not familiar to our people. Dulse, for instance, is a seaweed that has been used as a food in Ireland, and some of the other European countries, for many years, and is highly esteemed. The same may be said of some of the kelps, the periwinkle and the mussels. Among the new things here shown are the devil fish and the skate, which are said to furnish desirable food material, although it is not likely that the public will take to them readily, largely on account of their appearance. There seems to be little reason for this position, however, for the flounder, which has no claims for distinction on this account, is highly esteemed.

This question of habit and prejudice is a difficult one to overcome, as has been instanced in the efforts to introduce the tile fish by our Bureau of Fisheries. This is a beautiful and desirable fish, but because it is something new it is still regarded with suspicion, and but few people will buy it at any price. Another striking example is that of the pollack, a handsome fish that not so many years ago was not considered fit for human consumption. Today it is highly esteemed, and the very fishermen who formerly condemned it as a "bait stealer" now consider it a great delicacy.

The last of our illustrations shows some models of snakes, which are suggested as capable of utilization as food. It is not an attractive suggestion, still many kinds of snakes are much more desirable in their habits of living than some creatures that are popularly approved of; the crab and the lobster, for example. Still, in the old days when our western country was a trackless wilderness it is said that more than one wanderer on the plains found a rattlesnake stew not only palatable, but appetizing when other food failed them far from the habitations of man.

Many of the suggestions shown in the accompanying illustrations are not acceptable to the American people, who have always been accustomed to generous supplies of the best kinds of foods; but if the war continues another year, and the dealers in foods are permitted to pursue the same course in the future as in the past, we may still come to eating snakes, and be glad to get them. For a year past staple food stuffs, such as flour, cheese, sugar and meats, have sold in London from 30 to 60 per cent lower than in New York, even with exorbitant freight charges added—and still Congress hesitates over a law to regulate this matter lest too much power may be given to those charged with the supervision of food supplies. In the meantime the food speculator continues to exercise supreme and unrestricted power. To meet the emergency autocratic power is necessary, and not a timid law that affords innumerable and unlimited opportunity for legal quibbles and delays that practically nullify the ostensible regulations. We have seen how such laws operate in the case of our pure food regulations, which are largely nominal, and nominally enforced; and it is even hinted that these regulations should be relaxed in the present emergency—which is certainly not a proceeding in the interest of the public.

Human Psychology and Animal Psychology*

By C. Saint Saëns

Editorial Note.—Apropos of the views of Dr. Grasset upon human biology, some account of which was given recently in these pages, our readers will find the following observations by Mr. Saint Saëns, a distinguished member of the French Institute, of interest:

It requires a certain courage, some persons might even say of rashness, for an ignorant person to declare that he does not entirely share the views of such a savant as Dr. Grasset. If I venture, nevertheless, to do so, it is to undertake the defense of the intelligence of animals, which Dr. Grasset rejects as being completely outside the sphere of human intelligence. To be sure, we must guard against anthropomorphism; but do we not run the risk of falling into the error of Descartes in discarding it *a priori*, in wishing to deny it without taking experience into account? We are past the period when theories were glorified regardless of facts; and without going to the extreme of positivism that cuts the wings of hypothesis and takes account of demonstrated facts alone, we can no longer accept a theory, no matter how seductive it may be, if it is contradicted by the experimental method.

Led by my myopia to the observation of minute details, I have done much observing throughout the course of my long existence, from my tenderest youth up; and he would be deceived who thought he detected in the result of my observations the influence of the imagination of the artist; I have always observed phenomena coldly, conscientiously, letting my imagination reign in its own sphere, and not allowing it to intervene where it is not necessary.

If I fully understood Dr. Grasset,[1] he claims that the psychic function of man presents such characteristics that it should be the subject of a special psychology, which appears to me quite incontestable; and that what chiefly distinguishes man from other living creatures is intellectual superiority and the faculty of indefinite progress.

Neither intellectual superiority nor progress needs be demonstrated. Is this progress indefinite? This is the opinion of the imaginative; it is that of Victor Hugo. In reality, we know nothing at all about it; an impenetrable veil covers the future of humanity. We observe that all species after having progressed up to a certain point, have disappeared; no one knows whether this law is destined to be applied to the human species. Are the *specifically human* biologic laws of such nature as to preserve the human species from the general law? Nothing is less certain. But that is not the main question, which is this: "All living creatures which possess psychic neurons perform acts . . . which are truly psychic acts, acts of volition. But the act willed by man differs from the act willed by the higher animals in a very important characteristic: while, in the case of the animal, all acts are the direct and necessary consequence of its constitution and of its automatism reacting in its exterior environment, in man, on the contrary, there appears in his volitional and contemplated acts an entirely peculiar contingency, a direct intervention of the individual exerting volition which prevents the *prediction* of the act of the man as one is able to predict the action of the animal . . . The animal is predestined to obey the biological laws of its species, while man obeys them only if and when he will . . . He

*Revue Scient., Paris.

[1] See Revue Scient., Feb. 3, 1917, p. 65.

Preparing a specimen of the devil fish for exhibition. The wings have a fine flavor

Coloring a model of snakes. Some kinds of reptiles furnish acceptable food

may sustain with energy the pretension that two and two make five; he may commit suicide . . ."

The answer to the argument quoted in the preceding paragraph is that only a madman or a jester could sustain that two and two make five; we need pay no attention to this. But the conclusion drawn is that the animal is entirely lacking in freedom of action; that all his acts can be foreseen; that he is incapable of committing suicide.

No one who has seriously observed animals could make such affirmations. Without speaking of trained animals, accomplishing acts foreign to their nature, I could fill a hundred pages with observations demonstrating that animals are capable of observing, of reflecting, and of acting in accord with the result of their observations.

Let a few examples suffice:

In a small town near Paris, a female dog had her foot broken, and since there was no veterinary in the place she was taken to a doctor who performed the necessary operation. Some time afterward another dog having met with the same accident, the first patient conducted him to the physician. Shall I tell of my own dog, Dalila, going to hunt a lump of sugar for her mother and afterwards going to seek another for herself? Are these acts which could have been foreseen?

As for suicide it exists among animals. I have been a witness of that of a sparrow, captured, caged and unable to accustom itself to captivity. It committed suicide under difficult conditions, with a courage and a strength of will of which few men would be capable.

And how shall we regard the following observation made, not in the world of the higher animals, but in that of insects, so different from ours? It was in the forest of Fontainebleau. On a stone half a dozen ants gathered about a bit of squirrel dung were regaling themselves with avidity. From time to time I approached the group of epicures with my finger, at a distance of about a decimeter (about four inches distant); all the ants quit their repast, save one who did not see fit to disturb herself. Finally, I put my finger very close to the group; all the ants fled, except the one that had not been frightened before. She turned suddenly towards me, remained motionless a few moments, erecting herself on her legs and menacing me with her mandibles; then she rushed upon me with all her speed. . . .

This observation proves two things; that these little creatures are capable of reflection and even of an extraordinary courage; and that all the individuals of the same species do not act with predestined certainty in the same fashion.

I should be afraid in venturing into the realm of philosophy, of exceeding my strength and undertaking questions beyond my ability; I will only venture to remark that in speaking, apropos of human biology, of laws *non-experimental, eternal and immutable*, the learned doctor appears to me to be leaving the domain of science proper to plunge into theology; and that I entirely cease to comprehend him when he says that every one should bend, *freely, but obligatorily*, before certain laws.

To return to human and animal intelligence, its domain appears to me to bear a certain analogy to the solar spectrum, wherein we distinguished the infra-red, the visible position and the ultra-violet.

At one end of the scale I find faculties possessed by animals but denied to man; a sense of orientation, foresight of earthquakes, etc.

Then follows the region wherein the psychic faculties are *identical* in man and animals.

The other end of our scale comprises the immense extent of exclusively human intelligence.

The common region is perhaps extensible. There is nothing to prove that animal intelligence may not be perfectible, and many facts seem to prove the contrary.

As for the so-called instinct, whose name is given abusively, among animals, to faculties which are evidently psychical, it is the same in the nurseling and in the new-born animal; the essential and undeniable difference begins with the first smile of the tiny infant.

The skate is not handsome, but it supplies good food

Incipe, parve puer, risu cognoscere matrem! Nothing, therefore, is more legitimate than the study of a peculiarly human psychology, and the affirmation of a profound difference between human psychology and that of animals.

Only, in my opinion, this difference, so profound, is not absolute. Therein lies the kernel of the matter.

Buttons as a By-Product of Beer*

For many years the spent yeast which collected in immense quantities in the breweries and distilleries of Germany was looked upon as a bothersome waste product. Although a small proportion of this material found employment in the baking industry, the vastly greater part constituted an unmitigated nuisance. But of late this has been changed. In the first place, it was recognized that on account of its high content of albumen it was of potential food value. At first, on account of the bitter taste from the hops, the yeast was available only for use in the manufacture of articles like soup tablets. Later, means were found to remove this; so that by a process of sweetening and drying a large variety of tasty and nutritive food products were manufactured, suitable alike for human consumption and for use as fodders, and the entire yeast output of the breweries, amounting to 10,000,000 kilos annually, was in this way utilized.

Upon the subsequent discovery of means of increasing the albumen content of the yeast the manufacture of yeast food products graduated from the ranks of subsidiary industries, and plants of an annual capacity of many million kilos were constructed for the sole purpose of the formation and conversion of yeast. Of the magnitude of these plants some idea may be formed from the fact that the cement vats for the generation of yeast are the size of the largest swimming pools, and that the yeast compound stands two or three yards deep in them. But even then the surprises which the yeast has in store are not at an end. It has recently been found that on account of its plastic nature the yeast can be readily molded into any desired shape. This would at once suggest the possibility of a wide field of utility in the arts and in the manufacture of various small articles now commonly made of bone, horn, rubber, and various kinds of composition. The prospects of so utilizing the yeast did not at first appear encouraging. It was of a most unattractive, dirty, gray-brown color, and its consistency was not especially good.

However, after much experimenting, a process was discovered for dyeing it satisfactorily, as well as for graining it; and then means were found to control its texture within very wide limits. The worked-over yeast, styled "ernolith," has the form of a powder, which after dyeing is hot-pressed into any desired shape. These shapes may then be worked over mechanically—may be sawed, scraped, filed, drilled, bored, turned, engraved, ground to a keen edge, polished to the last degree. The material has an extremely close structure, with a conchoidal fracture, and it possesses sufficient hardness and elasticity for all ordinary purposes. Furthermore, it takes hold with a vice-like grip of metal parts pressed into it, so that wires, collars, etc., of metal may be firmly attached with minimum effort. As an instance of the advantage derived from this property, it has always been a matter of considerable difficulty to attach a metal shank to a bone or horn button. It has been necessary either to screw it in or to cement it in. With a button of ernolith, the shank is merely pressed in when the button is first formed, and it is then firmly fixed. Similarly, all manner of animal and vegetable fibres—wool, cotton, asbestos, etc.—may be pressed into the substance of the ernolith. A variety of articles can profitably be made of ernolith, extending into all branches of artistic and technical work. Buttons, door-bell plates, knife handles, are just a beginning, suggesting at once extension to handles and wall plates of every description. While its greatest appeal to German consumers at present is due to its ability to replace to a large extent many of the materials which the war has made scarce on the Continent, it will certainly remain in many of the fields which it has conquered as a very cheap and very satisfactory composition.

*From the *American Bottler*.

Long Reinforced Concrete Bridges

The Walnut Lane bridge, Philadelphia, has a reinforced concrete span of 233 feet; at Grafton, New Zealand, a span of 320 feet; at Rome, 328 feet; at Largweiz, Switzerland, 330 feet, and the proposed bridge over Syuyten Duyvil Creek, New York, 703 feet.

Military Motor Truck Design*

Interesting Facts Developed on the Mexican Border

By H. D. Church[1]

MOTOR trucks of American manufacture have played an important part in the present European war, but up to this time, our general design has not been materially influenced thereby.

The conditions on the western battle front in Europe are such that large armies have been practically in the same positions for two years, and this fact, in conjunction with the first-class French roads, has made it possible for the conventional design of American commercial motor trucks to render fairly good service.

In other words, the commercial motor truck of today is essentially a hard-roads vehicle, and when used over such roads, would naturally not require any radical changes in design to meet military conditions.

In event of any fighting on American soil at any time for several years to come, it is most improbable that similar conditions to those outlined above would exist. Our borders are so long that permanent trench fighting on a large scale is most improbable, and the roads in this country are far inferior to those of France or Germany. It follows, therefore, that a truck designed for satisfactory military operation in this country, which means for use in connection with mobile field operations over mediocre roads, or in some cases, no roads at all, must necessarily be of a design differing in many respects from our present type of commercial vehicle. Furthermore, the design of such a truck is bound to be influenced by the widely varying climatic conditions found in the United States proper.

During the trouble with Mexico, in the past year, our army, for the first time, depended almost entirely upon motor transport, using quantities of the leading American makes of conventional commercial trucks.

From the standpoint of quick development of a suitable truck for American army use, it is most fortunate that the operating and climatic conditions were extreme, as the result was to sharply define those points wherein a truck designed primarily for commercial service would not satisfactorily meet our military needs.

The experience of our army with motor transport for the past several months has resulted in a vast amount of information as to desirable changes in design, and the army has been most willing to extend to the engineers of the various truck manufacturers every facility to gather firsthand information on army requirements for motor transport.

It is the writer's opinion that for American army transport purposes, several different types of transportation will be required, according to topographical and road conditions.

1. Mule transport.
2. Caterpillar tractors.
3. Four-wheel driven trucks.
4. Two-wheel driven trucks.

Each of these methods of transport will probably be used, as each of them has a certain field of operation which cannot satisfactorily be filled by the other types. It is probable that the majority of the transport work will be done with two-wheel driven vehicles, as, where the road conditions will permit of its passage, this type will haul materials in the minimum time and at the minimum operating expense.

As the writer's direct experience has been largely with two-wheel driven trucks, this paper will be confined to consideration of that type, primarily of a nominal capacity of 1½ tons, this being the size which was most largely used.

GOVERNORS

One of the first and most important points in connection with the design of a military truck is the absolute necessity for governors on the motors, not only to limit the maximum vehicle speed on high gear, but also to limit the maximum motor speed on any of the gears.

Experience along the border with trucks which had never been equipped with governors by their manufacturers, as well as with trucks on which the governors had been removed to obtain more power, proved conclusively that a governor is even more necessary for trucks in army service than for those in commercial service.

From personal observations made along the border, it is the writer's opinion that the constant maximum motor speed governor is the proper type. This type of governor not only keeps the maximum vehicle speed down to a point where durability is assured, but it also keeps the motor speed down at all times, so that it is impossible to shorten the life of the motor by excessive speed when running on any of the geared speeds in the transmission. This is an important consideration for soft road operation where, if a governor which limits only the maximum road speed is fitted, there is a great temptation to the driver to run for long periods on second or third gear in the transmission with the motor racing, a practice which will materially shorten the life of the motor.

Governors must be thoroughly enclosed and sealed, to prevent their being tampered with without the knowledge of those in authority, and in order to obtain the best results, should be extremely sensitive, without "surging." A sluggish governor cuts into the power curve of the motor too early on acceleration and too late on deceleration; and experience has shown that a snappy governor action can be obtained within speed limits of 4 per cent on acceleration and 6 per cent on deceleration, which will utilize the maximum amount of horsepower for a given maximum governed speed.

ABILITY OR TRACTIVE EFFORT

Consideration of governors leads directly to the question of ability or tractive effort, both on high and low gears. To obtain the best results over soft road conditions, and *without* disconnection of governors, the average American commercial truck has insufficient high gear ability and far too little low gear ability to successfully pull its load through deep sand or mud or over extreme grades.

The average truck designed for American commercial service has plenty of ability on both high and low gears to successfully handle its load over hard roads and over the grades found in American cities, but the conditions of operation for army service in this country are much different.

The tractive effort required increases very rapidly with an increase in road resistance, and sand or soft going will not infrequently result in road resistances as high as 300 pounds to 500 pounds per ton, far in excess of anything ordinarily encountered in commercial service.

When it is considered that the road resistance in pounds per ton on good asphalt is 15, on macadam 50 to 60, and over ordinary cobbles 130, the necessity for an increase in tractive effort becomes very apparent.

For American military purposes, the low gear tractive effort should at least be sufficient to continuously turn the rear wheels of the fully loaded truck on dry asphalt with the truck itself stationary. Using a coefficient of friction between the tires and a dry asphalt surface of 0.6 and a total rear end loaded weight of 7,600 pounds for a 1½-ton truck loaded to capacity, the low gear tractive effort necessary to meet these requirements becomes 4,560 pounds.

Commercial truck practice now gives far lower figures. For example: the low gear tractive effort of what is considered a powerful 1½-ton commercial service truck in only 2,600 pounds. To safely carry the low gear torque required to give 4,560 pounds tractive effort, the driving members throughout, from the gear train in the transmission clear back to the rear tires, must be made heavier and stronger, which, of course, will result in an increase in chassis weight. From the standpoint of design, it is probable that any such increase in low gear ability for military service as outlined above will cause more changes in truck chassis design than any other one requirement, the necessity for which became apparent during last year's experience on the border.

MOTOR COOLING

The heat dissipating ability of the average radiator was found inadequate, a serious matter at any time, and more serious in a country where water is scarce. With the thermometer standing at 110 to 120 degrees in the shade and the truck using maximum motor power on low gear for long stretches, extraordinary motor cooling ability is required. Probably an increase of 50 per cent over average commercial practice would not be excessive, and a desirable provision would be a simple means for reducing the radiating area for efficient use in the cooler sections of this country.

When a truck is pulling along through heavy sand on low gear, its speed is so slow that the air circulation through the radiator resulting from the movement of the vehicle can practically be disregarded. This means that the radiator fan must handle a large volume of air in order to keep the motor cool under these conditions. In the writer's opinion this is not so much a question of efficient fan design as it is of furnishing some means of driving which will keep the fan up to its normal operating speed. The belts used for driving the fans on the average commercial truck are not sufficiently powerful to properly meet this condition, and either the size or design of belt will have to be changed, or some positive drive provided for the fan.

This is an important point, for if the radiator design is such that it depends upon the fan circulation to give a certain cooling ability, the result is seriously affected if the fan does not at all times draw approximately the volume of air that it handles when its belt is new and tight. A feature of the radiator which should be given careful consideration is its mounting, which should be such as to minimize any strains in the radiator proper which are set up as a result of excessive chassis frame deflection. Furthermore, the radiator should be of a type which has large water passages, is least liable to break under distortion, and which is readily repairable in the field.

TRANSMISSION GEARS

Army experience on the border clearly showed the desirability of four-speed instead of three-speed transmissions for military purposes. If the low speed reduction ratio in a three-speed transmission is made great enough to give proper low gear tractive effort, the steps between speeds become so great as to interfere with easy gear shifting. Furthermore, the four-speed gear box has the very important advantage over a three-speed box for soft road service of always having a gear ratio more nearly adapted to any particular road requirement than can be obtained in a three-speed box.

It is probable that the gear ratios in a four-speed box for military trucks will be so arranged that second speed will be used for normal starting on hard road surfaces, and that the first speed, or low gear, will have a greater reduction ratio than anything which has been built to date. This high reduction ratio low-speed gear will then be in reserve for starting or running in deep sand or mud or for climbing steep grades. In effect, such a combination of gear ratios would practically result in adding to a three-speed gear box of the conventional ratios an extra low gear with an extremely high reduction ratio, to be used for starting or running in sand or mud or for climbing steep or soft grades.

CONTROL ELEMENTS

The desirability of standardizing the control elements has been clearly indicated. When large fleets of trucks are operated by a single user, particularly if the trucks are kept in operation for more than 10 or 12 hours out of 24, two shifts of drivers are necessary, and there is bound to be a certain amount of shifting of drivers from one make of truck to another. Where drivers are called upon to drive different makes of trucks, they should be able to do so with facility, and much time would be saved and better average operation assured if the same motion of the driver's right or left hand or foot could produce the same result irrespective of the make of truck. Standardization of controls along these lines would not only result in more economical and efficient operation, but would also simplify the instruction of drivers.

WHEELS

The use of all-metal wheels will undoubtedly receive careful consideration as a result of border experience, in spite of the fact that the wood wheels with which the majority of trucks were equipped gave remarkably good service. For desert running in the northern Mexican or southwestern United States climates, any wood wheel, no matter how good, will eventually loosen in the spokes, and all-metal wheels are essential for durability in such climates.

On commercial trucks of three tons' capacity and under, steel wheels are not extensively used due probably to the fact that for normal service wood wheels are perfectly satisfactory, and also because a set of steel wheels for a truck of two tons' capacity or less will weigh approximately 125 pounds more than the corresponding wood wheels. For military service, however, which is bound to be extreme, any objection from the standpoint of slightly increased weight is more than offset by the necessity for durability under any climate condition.

WHEEL GAGE OR TREAD

Wheel gage or tread is most important when numbers of trucks of different makes and sizes are operated over

*A paper presented before the Cleveland Engineering Society, reprinted from the *Journal* of the Society.

[1]Chief Engineer Truck Division, Packard Motor Car Co., Detroit, Mich.

the same routes on soft roads, and trucks for American army service ought to have a specified standard gage in order that each different size or make may not have to break down a new track in the roadway.

If all sizes of trucks could be made to the present standard road gage of 56½ inches, such standardization would be of the most value from a commercial as well as a military standpoint, as it would facilitate the operation of all trucks over soft country roads. Such a narrow gage is impractical for large trucks from three tons' capacity and up, owing to constructional limitations. It would appear, therefore, that the best compromise from a military standpoint would be to ascertain how narrow it is practical to make the gage of the larger trucks and then to increase the gage of smaller trucks to a point where their tires will run within the tracks made by the wider tires of the larger vehicles.

From a commercial standpoint, this plan would slightly impair the usefulness of the smaller sized trucks on soft roads, but if the gage finally decided upon is not so much above 56½ inches that the wheels on one side can obtain no advantage at all from one of the 56½-inch tracks on the road, the objection is not serious, while any approach to a narrower gage on present day large commercial trucks would somewhat help their performance over soft roads.

Such a standardization of wheel gage would be of immense value on trucks for military purposes, and in the writer's opinion, would probably tend to increase the field of profitable operation for commercial trucks.

FINAL DRIVE

It is evident that the best results will be obtained from some form of fully enclosed final drive, which should be so thoroughly enclosed as to retain lubricant, and to prevent deposit of fine dust or grit on any of the working parts.

Whatever form is used, either worm, internal gear, or double reduction, it should, in addition to the above requirements, be capable of efficiently and continuously transmitting the maximum low gear torque of the vehicle without overheating, and give at least 10 inches road clearance with 36-inch diameter wheels.

A highly desirable feature would be the use of some form of differential which will *automatically* prevent one wheel from spinning if it loses traction, and which will still function as a differential when the truck makes a turn.

The torque transmitting members throughout the rear axle, and through the entire driving train as well, should be able to stand, without overstressing, the sudden engaging of the clutch, with the transmission in low gear, the motor running at maximum governed speed, and the truck rear wheels locked.

BRAKES

The development of a braking system suitable for a military truck presents severe problems in regard to cooling.

The brakes as used on our commercial trucks of today are not well enough cooled to stand up long under some military conditions, as for instance, handling the fully loaded truck on a three-mile descent on a hard road surface with grades running up to 25 per cent, and averaging 7 per cent.

Brakes as designed have sufficient power to hold the truck under such conditions, but will heat up so that the linings char slightly and wear rapidly. Water cooling is undesirable, and it is probable that some type of metal-to-metal brake will be necessary, which, while not as smooth in action as, and noiser than, the conventional brake faced with brake lining, will give greater durability under continuous application.

DUST PROTECTION

It is essential that thorough means be provided to keep dust and grit out of all working parts. Troubles from dust are more liable to result on trucks in military service than on those in commercial service, due to running in "fleets," or trains, over country roads.

Along the Mexican border, during the dry season, which means for the greater part of the year, there is an extraordinary amount of very fine, powdery dust, and a "train" of trucks running at 12 or 14 miles an hour will raise a dust cloud which is visible for miles. This fine dust is drawn into the motor cylinders through the carburetor intakes, acting as an abrasive on the pistons, piston rings and cylinder walls, and some is apparently drawn into the crank case through the breather, mixing with the lubricating oil and causing undue wear on all working parts of the engine. Some form of separator or air strainer for both the carburetor and breather would be highly desirable, but it should be of a simple type, not requiring too frequent cleaning, and should not be of any form requiring water.

ROAD CLEARANCE

On a military truck, the question of road clearance is of great importance. Not only should a minimum clearance of 10 inches at the center of both the front and rear axles be maintained, but the clearances under the steering knuckle levers and the steering cross tube ends must be as great as possible. Furthermore, unusually high road clearance is desirable under the chassis, midway between axles, to prevent contact with the ground when the truck is driven over a bank into a river bed or over a ridge.

RESULTS OF FRAME DISTORTION

To take care of excessive frame distortion, which is unavoidable when operating over rough or soft roads, the radiator, motor and transmission should be carried on three-point suspensions, and with clearances sufficient to obviate any possibility of their being themselves distorted. Provision should be made to protect the steering column from any binding from the same cause, and all connections between the rear axle and frame should be arranged to permit the maximum horizontal misalignment between the two without overstressing or breaking any of the connecting members. The gasoline tank mounting should also be carefully arranged to protect the tank from twisting strains.

CONCLUSION

It is impossible, without writing an unduly long paper, to take up all the points in the design of our conventional trucks which will be more or less influenced by military use.

Many other points will be affected, such as motor lubricating systems, carburetor design, steering gears, springs, body design and attaching means, etc., but the points discussed above are, in the writer's opinion, the ones which will require the greater changes in design to render our commercial trucks suitable for military use in this country.

The War Department has made a careful analysis of motor transport, and is now drawing up a specification to cover a desired design of two-wheel driven trucks, for service with our army.

It is improbable that any subsidy plan for military trucks, similar to the English War Department subsidy plan, will ever be put into effect in this country.

In the absence of such a plan, it is probable that the United States War Department specification, when issued, will stand as a sort of master specification for American truck manufacturers, in that, as they bring out new models from time to time, they will incorporate in the design such features specified in the War Department specification as will not detract in any way from the commercial value of the truck, and, at the same time, so design the other parts that with minimum change, modifications could be added to meet the balance of the specification. If this procedure is followed, the War Department will eventually be able to purchase, at comparatively short notice, trucks which much more nearly meet its requirements than anything on the market today; and, furthermore, many of the features found necessary from army experience on the Mexican border will, if incorporated in our commercial trucks, materially enlarge their operating field.

An Ionization Manometer*

By O. E. Buckley
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HERETOFORE the only manometers available for measuring extreme vacua have been the Knudsen manometer and the Langmuir molecular gage. Both of these have serious disadvantages due to their delicate construction and slowness of action. A new manometer free from these objections and with a greater range of pressure than either has been developed. This manometer makes use of the ironization of gas by an electron discharge.

The manometer consists of three electrodes sealed in a glass bulb which serve as cathode, anode, and collector of positive ions. The cathode may be any source of pure electron discharge such as a Wehnelt cathode or a heated tungsten or other metallic filament. The exact forms of the electrodes are not of great importance. The collector is preferably situated between the other two electrodes and of such form as not to entirely block the electron current to the anode. A milliammeter is used to measure the current to the anode and a sensitive galvanometer to measure the current from the collector which is maintained negative with respect to the cathode so as to pick up only the positive ions.

If there were no gas at all in the space between the electrodes a pure electron current would flow from cathode to anode and no current would flow to the collector. However, if gas is present positive ions are formed by collision in amount proportional to the elctron current and the number of gas molecules in the space. Since the collector is negative with respect to the cathode a certain proportion of the positive ions, depending on the form, dimensions, and potentials of the electrodes, will flow to the collector. Hence the ratio of the collector current to the anode current is proportional to the pressure and may be used to measure the pressure when the constant of proportionality has been determined.

This relation has been tested experimentally with air over a pressure range from 10^{-3} to 4×10^{-8} mm. of mercury by comparison with McLeod and Knudsen manometers. The actual apparatus used consisted of a glass bulb 6 cm. in diameter enclosing three parallel V-shaped filaments of thin platinum strip, each about 3.5 cm. long, placed 5 mm. apart, the collector being between the other two. Leads from both ends of each filament were brought through the glass. This arrangement permits glowing the electrodes to free them from occluded gases. An oxide coated filament was used for the cathode. The bulb was sealed to a large glass reservoir which was connected to a high vacuum pump and either the Knudsen or McLeod manometers. When the latter was used a liquid-air trap served to keep the mercury vapor of the McLeod manometer out of the ionization manometer.

Currents from 0.2 to 2.0 milliamperes were used with from 100 to 250 volts between cathode and anode. The collector was held at 10 volts negative with respect to the cathode. The resulting current to the collector at a pressure of 10^{-3} mm. was about one-thousandth the current to the anode and at lower pressures was proportionately less. Hence at a pressure of 10^{-8} mm. with a current of 2.0 milliamperes to the anode a collector current of 2×10^{-9} amperes could be obtained. With a sensitive galvanometer much lower pressures could easily be measured.

Experiments with hydrogen and with mercury vapor in place of air gave constants of proportionality nearly nearly the same as with air.

The advantages of this type of manometer are readily apparent. Its range compared to that of other high vacuum gages is very large, extending from more than 10^{-3} mm. to as low pressures as can be obtained, with out any change of apparatus. On account of its simplicity of construction it is inexpensive and exactly reproducible. Since there are no moving parts there are no difficulties due to vibration. The pressures of vapors which would not be registered on the McLeod gage are measured by the ionization manometer. One of the greatest advantages is the rapidity and ease with which measurements of a varying pressure may be made since only the reading of a galvanometer need be followed.

Many applications for which other manometers cannot readily be used at once suggest themselves, such as the measurement of vapor pressures of metals, etc. Since the device may be made with extremely small volume the pressure of very small quantities of gas may be measured. It would also be useful to measure pressure changes over a long period of time for which more expensive manometers could not well be employed.

A number of interesting physical measurements other than the measurement of pressure can be made with devices operating on the principle of this manometer, among which is that of the removal of occluded gases by electron bombardment. It is also hoped that experiments with various gases will give some information as to the relative cross sectional areas which different kinds of molecules present to the electron discharge, for although the constant of the manometer was found approximately the same for hydrogen, air, and mercury vapor, more exact measurements might show differences due to different molecular diameters.

* *Proceedings of The National Academy of Sciences.*

Corrosion of Tinned Sheet Copper

THE Bureau of Standards has recently investigated a rather unusual and interesting case of corrosion, namely, that of the roofing material of the Library of Congress. The roof of this building has been covered since about 1893 by tinned sheet copper which has become covered within the last ten or fifteen years with small pits; in many cases these pits have extended completely through the sheet. Such a condition is interesting, particularly in view of the fact that Washington is uncommonly free from smoke, etc., which is ordinarily understood to be a strong accelerating factor in corrosion. The investigation has shown that the corrosion was due to no accidental inferiority of the material, but that it is to be considered as characteristic of all material of this type. It, therefore, appears that tinned copper is not superior in any way to tin plate for roofing material and that in view of its greater cost can no longer compete with it.

Tinned sheet copper is used also for containing vessels such as milk cans and for fittings such as troughs, etc., for soda fountains and breweries. It is probable that such articles would also be subject to pitting corrosion of the same type if they are not worn out by actual abrasion before the corrosion proceeds far. Technologic Paper No. 90, describes this investigation.

Trench Building Animals*

And Their Expert Engineering Work

By Henri Coupin

Trench-digging animals are found in every group of the animal kingdom, from the most highly organized to the humblest. Mammals have an important place among them in our own land as well as in others. One of the first examples that comes to mind is that of the moles, which are past masters of the art of tunneling the ground and hiding themselves from view. They are aided in this subterranean road making by their broad fore-paws, which act at once as picks, shovels and rakes. If one of them is plucked from his retreat and placed on the ground, he digs himself in so quickly that he disappears in the flash of an eye, then proceeds to establish a system of complicated underearth channels, beside which the *boyaux* of our enemies are but toys.

To follow him therein is a difficult matter and to succeed one needs the long practice of professional mole-hunters. The mole is not content with establishing rustic galleries; at certain spots it constructs a "dungeon" which serves it as general living quarters. According to Blasius there is a circular chamber in the interior of the dungeon, from 8 to 10 cm. in diameter (3 or 4 inches), serving as a place of repose. This is surrounded by two concentric circular passages, the external one arranged on the same plane as the chamber, the internal one on a slightly higher plane. From the chamber proceed three passages, which, running obliquely upward, open into the internal circular passage; this is connected with the external circular passage by 5 or 6 oblique descending passages, alternating with the first set. From there radiate 8 or 10 tunnels, alterating with the before-mentioned passages; these run in every direction and describe a curve in order to open into the principal gallery. A safety tunnel descends from the chamber, then curves upward to the surface of the ground, ending in a ventilating tunnel.

The walls of the dungeon and the galleries are thick, smooth and strongly compacted. In the chamber is a bed stuffed with leaves, grass, young plants, straw, which the mole has in large part gathered on the surface of the earth. If danger surprises him from above he pushes this couch aside and descends. If he is attacked from the side or from below, some of the passages communicating with the internal circular passage remain open to him.

The fox, though more fond of open air, also passes a part of his existence, especially in the daytime, in a hole which he has dug in a favorable spot; and often, too, in one which he has appropriated from another animal so as to have only the trouble of arranging it to suit himself. These dens are in general deep chambers whose ramifications end in a large cul-de-sac. The chambers are arranged around the principal burrow, which has a depth of 3 meters (about 10 feet), a perimeter of as much as 15 to 20 meters (about 50 to 65 feet), and a dungeon a meter in diameter (3¼ feet). The galleries communicate with each other by transverse passages and have various openings to serve in case of flight.

The badger also seeks security in an almost subterranean existence. As Brehm says, the strength with which he is endowed enables him to burrow in the earth with surprising rapidity; in a few minutes he has dug himself in completely. "His vigorous forepaws, with fully united digits armed with solid nails, are of great aid to him. When checked by the earth which he is obliged to remove, he throws it far from him by the help of his hind-paws; but as the work advances, these means are insufficient; he then walks backward, thus sweeping the earth out and away. Of all the animals which inhabit burrows, the badger is the one who gives its habitation the greatest extent, and takes the greatest precautions in the interest of safety. The runways are all 7 to 10 meters (26 to 32 feet) and their openings are some 30 paces apart. The dungeon has a depth of a meter and a half under earth (about 5 feet); if it is on a steep slope this depth is sometimes as much as 4 or 5 meters (13 to 16 feet); but in this case there are almost always certain passages which end vertically and serve for ventilation."

The hamster also digs wonderfully well by the aid of its paws and even of its teeth; it throws the earth behind it, and when the quantity is sufficient it walks backward in order to push it through the opening.

The rabbit, as every one knows, also lives partly in burrows, each consisting of a dungeon whence depart many narrow and tortuous avenues. The marmoset in spite of its heavy aspect, is not less skillful as a digger; its galleries, so narrow that one can hardly thrust a fist within, lead to the residence proper, which has the form of a large basin. The entrance is sometimes found on the open turf; but most often it is hidden among rocks or under stones. The galleries mount and descend;

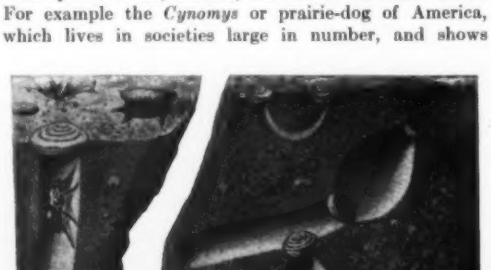
The badger and its young

they are simple or divided into many branches, in which the earth is well compressed.

The foregoing relates to the mammals of our own

The ordinary fox

country. We can, besides, find others in other lands. For example the *Cynomys* or prairie-dog of America, which lives in societies large in number, and shows



Burrows of the mygale, showing covers at the various entrances

plainly where it lives by its little mounds—block houses we might call them today—so numerous that the natives call them villages. According to Baldwin these mounds are usually 5 or 6 meters apart (16 to 20 feet); the little dome before the entrance of each is formed of earth which the *Cynomys* have thrown out from their tunnels. These dwellings have one or two openings; a beaten path runs from one to the other.

Another interesting exotic animal of this sort is the Fennec fox, which lives in the deserts of the north of Africa. Its runways are generally near the surface and its dungeon is not situated very deeply. It is a sapper of the first order; its fore-paws work with such rapidity one can hardly follow their motions with the eye. This skill in digging rapidly often saves its life, for it disappears from the sight of the enemy in a few minutes.

Let us cite further the *Spermophiles* or ground squirrels whose dungeon is more than a meter (3¼ feet) in diameter and from which run passages near the surface of the earth; the armadillos *Chlamydophores*, whose paws recall those of the mole and who dig veritable grottoes in the earth; the duckbill *Ornithosynchus* which constructs its burrows in the banks of rivers in such wise that one opening is under water and the other in the bank.

It is not strange that mammals, with four feet, armed with solid nails, should be able to tunnel the earth like mere *poilus* but it is singular to find similar customs among birds, creatures fond of the open air, and generally frail of build.

A good example of these is the bank-swallow which lives in colonies along cliffs and digs deep holes well above the level of high water. As Naumann says, "It is hard to explain how a little bird, so feebly organized, can execute such a gigantic task in so short a time. In two or three days a pair will dig a cavity 5 to 8 centimeters (3 to 4 inches), in diameter at the mouth, still more spacious at the bottom, and into which there opens a passage a meter in length, sometimes two meters. At this time the activity of these birds is almost miraculous. One sees them painfully gathering in their claws the earth they have detached and throwing it outside their dwelling. They often abandon a structure already begun; sometimes they have even finished the cavity, and begin anew. What motive causes them to act thus? We are completely ignorant. They are so busy digging one might think they had fled the country; but a knock on the ground is enough to make them hasten outside. The tunnel, at about 1.3 meters from the opening, opens into a not very spacious chamber, where the nest is found.

Curious, too, is another bird, the *Geositta*, which the Spanish call *carita, i. e.*, the little mason, which nests at the end of a narrow burrow extending horizontally for a distance of 2 meters (6½ feet).

"Some of the natives told me," writes Darwin, "that children often try to disinter the nest, but never succeed. The bird chooses a little declivity of sandy, but solid, soil on the border of a road or a stream of water. Here (in Bahia *blanca*), the walls are made of earth. I observed that the one surrounding the courtyard of the house where I am staying was pierced in many places with round holes. I asked the proprietor about it; he answered by complaining bitterly of the mason birds, and later I myself was able to observe them at work. A singular thing is that they appear to have no idea of thickness; otherwise they would not try to dig their burrows in these clay walls, whose dimensions they ought to know, since they are continually flying round about them. I am persuaded that when the bird suddenly finds himself in broad daylight again, after having pierced the wall, he is filled with stupefaction and is unable to explain so extraordinary a fact. I quite believe that in reality they seek no explanation and recommence their miner's work elsewhere, where man has not come to upset nature."

But we do not need to go to foreign lands for birds which dig in the earth. A well-known species, our pretty kingfisher, is skilful enough at this operation. To shelter itself from its enemies it establishes itself on a dry river-bluff. There, at about 50 centimeters below the upper edge (20 inches) it digs two round holes 5 to 6 centimeters in diameter (2 to 3 inches) from which lead two long passages which rejoin each other in a single tunnel which itself terminates in a rounded excavation 6 to 8 centimeters high (2½ to 3 inches) and 11 to 14 centimeters wide (about 4½ to 5½ inches). The bird spends two or three weeks in digging this. When it encounters stones it tries to lift them with its powerful beak; if it does not succeed it lets them lie and digs around them, which sometimes renders the tunnel very tortuous.

Skilful as they are, however, the birds must yield the

*Translated from *La Nature*.

A prairie dog village

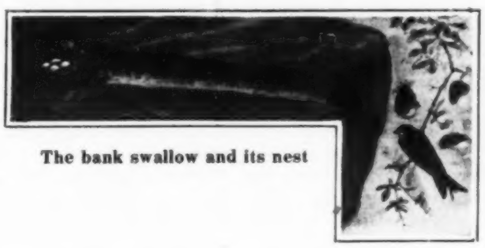
palm to certain spiders, which, for once disdaining the treacherous threads stretched in the open air, live in the earth, which they know how to handle with all the skill of an officer of the engineers. The classic example is that of our *Mygale*, which knows how to dig in the earth cylindrical pits, vertical or a trifle oblique, whose orifice is covered with a movable lid opening like the lid of a box, the hinge is made of silk and moreover, the spider takes care to construct tiny apertures in it, into which its nails can penetrate when, menaced by an enemy, it would fain keep its domicile from being violated. The mason *Mygale* therefore invented at once the hinge and the bolt.

In distant countries there are other species of *Mygales* which are more ingenious still. One of these, the *Rhytidicolus structor* of Venezuela, very common on sloping ground of compact, sandy soil, inhabits, according to a recent description by M. Simon, a burrow composed of three spacious chambers in succession. The chambers, which are slight enlargements of the burrow, communicate with each other by narrow openings each provided with a hinged lid, so that if an enemy has crossed the first trench, he encounters the second, and then the third, affording a probability that he will not reach the bottom, the last refuge of the ingenious eight-footed sapper.

Another species of *Mygale* in Venezuela, the *Stothis astuta*, achieves security in another fashion; it arranges its domain in the form of the letter U, and the two extremities, which both open on the surface of the ground, are each provided with a lid. When one cover is forced the *Mygale* can gallop apace to the other, lift the lid and take to his heels across country.

The fennec fox

Mole in its gallery, and skeleton of its paw



The bank swallow and its nest

The mole cricket

It would take too long to enumerate all the insects that dig trenches for themselves or for their progeny.

Let it suffice to recall the mole-crickets, or *courtilieres*, which profit thereby to devour the roots of the plants which we cultivate in our kitchen gardens; the crickets which the little boys know how to stir from their retreats by a straw; the white worms and innumerable other larvae; the termites, which moreover erect voluminous dwellings of earth solidly packed, though well mined; the ants, etc. These latter merit special mention because of their skill in establishing those communications which play such a great rôle in the trenches of today. The "*Lasius niger*" for example, digs roads at the surface of the ground and generally utilizes the excavated earth, when it is humid, to cover them with a vault of masonry, one might almost say of armored concrete.

At certain very exposed places it pierces tunnels which issue from the earth farther on to continue in a new covered road. When the road passes along a sheltered place, such as the foot of a wall, the ants omit the vault. It is the same way when the "*Lasius niger*" cross a main road; they try to build vaults, but these are constantly destroyed. It will be seen what a varied and interesting aspect these roads present.

Huber, from whom we borrow these details, speaks of having seen one which was completely vaulted and made of earth; it was barely a centimeter high (.39 inch) by 1 to 2 centimeter in width and mounted the side of a high wall; it afterwards crossed the top of the wall and redescended the other side to the ground; all this pains to pass from a courtyard into a garden.

Verily, ants are tenacious of their ideas.

Old Tactics and Discarded Armaments Brought Back to Life by the Present War

By George Nestler Trioche

THE old saying, "There is nothing new under the Sun" comes nearer to the truth in military matters than any other branch of human activity. Indeed, tactics, weapons and armaments used in the present war and which differ widely from those hitherto familiar to us, are, to a great extent, resurrections of methods and implements discarded long ago.

Let us consider, for instance, *Trench warfare*. Under some form or other, it is as old as war itself. The armies of the ancients made a far greater use of coverts than people generally believe. But the best instance of that tactic in the old time is found at the battle of Alesia where Caesar, who was engaged in a siege, found himself surrounded by trenches constructed by the relief forces of Vercingetorix. Romans and Gauls fought, then, nearly two thousand years ago, somewhat like European soldiers are fighting now on the Somme or at Verdun. This is quite natural, for victories won quickly by onslaught in the open are only possible when one of the adversaries is manifestly weaker than the other.

Trench warfare has led to great changes in the way of quartering troops. For centuries European soldiers, in time of war, used to camp. After 1870, the example of the Germans caused the general adoption of the lodging of men and horses in villages more or less near the seat of operations. Today, houses and barns in the fighting zone are destroyed; soldiers usually have to live either in *dugouts* close to the trenches, or in *huts* at some distance on the rear. Now, the scarcity of villages, and the insufficient shelter afforded by tents, compelled troops, before the Christian era, to build log cabins or to dig caverns on the hillside, whenever operations were of a protracted nature in a certain locality.

Nor is the so-called new German tactic—*the mass formation*—a real innovation. The hurling on the adverse lines of compact waves of men is a practice as old as the hills. It made the Greek phalanx famous, and was the main infantry tactic in the medieval period. It was discarded later, for humanitarian reasons, as artillery fire became more effective. But, unfortunately, such considerations have since lost much of their value, and thus we see the Germans follow the example of the Japanese at Port Arthur, and revert, on an unheard of scale, to methods of attack apparently defunct.

Machine guns have become, of late, most important factors. Yet the adjunction to infantry units of squads armed with heavier weapons than the rifle was common 400 years ago. Light guns were attached to infantry regiments or even battalions. And as early as the sixteenth century, there were, in Switzerland, crude models of small field pieces with several barrels.

One of the most interesting returns to obsolete weapons is seen in the case of *grenades*. These fell into disuse as soon as long distance fighting became the rule. Grenadier organizations either disappeared or simply became "crack" corps of infantry—regiments with a glorious past. Nowadays, all infantrymen are grenadiers in the trenches.

In this connection, it may be mentioned that the men who, now, at the front, are firing the little devices used to throw grenades farther than could be done by hand, do not generally know that early in the eighteenth century Germany and Switzerland had mortars, called *Cohorn*, specially designed for that purpose and more effective than those of today.

Speaking of machines, trench and aerial warfares have been creating a new use for all kinds of *old engines*. Different sorts of ballistas and even cross bows are resorted to at present and found very efficient. As for the famous British *tanks*, nobody can read a description of them without being remembered of the war chariots of the ancients.

Even the use of *gases*, either asphyxiating or incendiary, is simply an old method of fighting modernized and made more brutal. The Greek Fire, well known at the time of the Crusades, had, as component parts, besides asphalt, two of the main chemicals of today, niter and sulfur. Earthen vessels full of burning pitch were also commonly thrown upon troops storming a city or a fort.

To the layman who, for the first time, looks into the machinery of field guns, it is always pointed out emphatically by the artillerymen that one of the greatest improvements in the gun carriage is the folding *shield*, which protects the gunners. But he is not told that in the fifteenth century, some of the earliest models of field guns were provided with this device, which disappeared for nearly 500 years.

If the layman wants to penetrate deeper into technicalities, he will learn that a great change has been made in the disposition of a battery for action: *limbers and teams* remain no more back of and in the near vicinity of the pieces; they are sent to the rear, so that drivers and horses should not run unnecessary risks. But that "new way," adopted towards 1895, is, in fact, a resurrection of the early artillery tactics, according to which the hired teamsters were practically never under fire and ammunition chests were carried by hand to the position of the guns.

A fact that has attracted very little attention is a so-called new formation taken by infantry units to shelter themselves, when in the open, against fragments of shells exploding in large number above the heads of the men: the latter kneel on the ground as close together as possible, bending the head so as to hide it under the huge knapsack which thus is used as a shield. This formation is not anything else than the "turtle," of the Roman Legion.

As for the *helmet*—the homely, already famous, almost epic helmet of the Allies—little is to be said. The traditional metallic headgear of the warrior was practically abandoned as the use of firearms increased. It degenerated into gorgeous felt hats, cumbersome leather "shakos," etc., until it dwindled into a plain cap, which, in the case of the French, afforded no protection whatever, even against rainfall. Today, it has been found that, after all, the most effective headdress of the soldier is the plain helmet used by his remote ancestors, the infantrymen of Burgundy, under Charles the Bold.

Oil Tanks for the British Navy

IN view of the rapidly increasing use of oil fuel in war vessels it is interesting to note that the British Admiralty is building twenty big oil tanks, and an immense underground reservoir for the storage of oil, which it is said will be the largest in the world used for this purpose. The size of these tanks and reservoir is not stated, but the cost is estimated at about a million dollars.

The Propagation of Electric Waves*

At the Surface of the Earth and the Ionized Stratum of the Atmosphere

By H. Nagaoka, Professor at the University of Tokio

The hypothesis according to which the superior layer of the atmosphere is ionized and forms a reflecting surface for electric waves seems to have been just formulated by G. F. Fitzgerald[1] and by O. Heaviside[2], though neither of them assigned any cause for ionization. The same idea has been utilized by A. E. Kennelly[3], and especially by Ch. Ed. Guillaume,[4] with more details, to explain wireless telegraphy at a great distance; they consider that the space within which the electric waves are propagated is in great part confined in a sort of spherical shell of a di-electric medium in which the waves are guided by the ionized stratum and the earth acting as a conductor in such manner as to travel without a great loss of energy, as would be the case if the propagation took place according to three dimensions.

The object of this paper is to develop the same idea, by giving an account of the processes of ionization and of its diurnal variation. If we accept the theory of the partial reflection of electric waves by the ionized stratum we shall be able to resolve into their general features the problems of the singular influence of the approach of, the rising and the setting of the sun upon the signals of wireless telegraphy, of the difference in the degree of transmission along meridians and parallels, of the presence of wandering currents, and of other related subjects.

The first question which demands a careful examination is that of the seat of the ionizing agent and of the processes and the conditions in which the upper layer of the earth's atmosphere is ionized. The existence of such a layer and the constant capture of ionizing corpuscles seems demonstrated by the experiments of Birkeland[5] and by the theoretic conclusions of Störmer[6].

The latter has calculated the orbits of electrified corpuscles, of which we have strong reason to believe that the solar surface emits an abundant flux. The complicated solutions obtained for these orbits, according to the initial speed of the corpuscles, the direction of emission, and the force of the field which acts upon them, acquire a high importance when we compare them with the experiments made by Birkeland with an artificial spherical magnet bombarded by cathodic rays in a large container in which a vacuum has been produced. Although these experiments had for their initial object the explanation of the phenomenon of the aurora borealis, the problems they resolve are intimately connected with the question we are discussing. The existence of auroral zones not far from the magnetic poles, corresponding to the corpuscular bands, the existence of three spots in the "terrella" of Birkeland, the fringes of the auroras, the rings of corpuscles around the magnetic equator, and other facts have been proved by a series of mathematical reasonings deriving from the usual magnetic equations. The objections which may be made against this mode of treating the problem are the negligence of the magnetic action of the sun, which is, however, very doubtful, and its electrified condition, for we have reason to believe it is positively charged, as Arrhenius believes[7]. The variation in the afflux of the electrified corpuscles to the sun and their capture by the earth must modify the mutual potential between these two celestial bodies, in such sort that the force acting upon the electrified corpuscles will doubtless be also subject to the variations accompanying solar activity. The quantitative result should be examined more in detail, but the general traits of the phenomena observed on the surface of the earth will not be materially altered, as is sufficiently indicated by the actual observations on the variations of terrestrial magnetism, the polar aurora, and the related phenomena. I propose to introduce among these last the phenomena observed during the transmission of wireless messages.

When we speak of the bombardment of the electrified corpuscles emitted by the sun it seems that the process would take place only during the day, and would be confined to that part of the earth's surface turned towards the sun . . . so that the difference between day and night would be very pronounced as far as concerns the ionization by electrified corpuscles. But the special merit of Störmer's calculation consists in this, that the capture of electrified corpuscles does not vary much whether the earth is turned towards the sun or not.

Birkeland's experiments likewise confirm these results, so that the bombardment of the earth by the corpuscles, and the consequent ionization of the upper layer of the atmosphere, differ little in the day and the night, which may seem at first glance highly paradoxical.

I have shown elsewhere[8] how we may account for the abundant emission of electrified corpuscles by the presence of clouds and of facules of calcium in the sun, by considering that an action analogous to that of Wehnelt's cathode in a vacuum tube takes place on a colossal scale at the solar surface. The afflux of corpuscles from the solar surface will be continually subject to various changes, and the effect which must result, directly or indirectly, on the earth's surface, will be felt equally upon the latter whether it is turned towards the sun or is in the shade.

The ionization of the upper atmosphere is not limited to that produced by the corpuscles, but the ultra-violet end of the solar spectrum also has an important part in it. This acts only during the day; what remains during the night is only the residue of the ionization produced during the day and not yet neutralized by the recombination of the ions. According to the observations of Dorno,[9] of Wigand,[10] and of others, the part of the solar spectrum whose wave-length is less than 0.29 μ is completely absorbed in the atmosphere at altitudes above 9,000 meters. The absorption may take place partly in the photosphere, but the radiation of a black body at 6,000° C. for wave-lengths lower than 0.29 μ comprises a considerable portion of the total energy emitted, as is shown by a simple construction of the curve of energy according to Planck's law.

We have good reason to believe that the energy of the ultra-violet radiation is principally expended in the production of the ionization of the atmosphere, probably above 10 km. of altitude. The electrometric observations of Wigand[11] in a balloon ascension show that the degree of ionization does not increase in a manner directly proportional to the height, but that the rapidity of increase accelerates rapidly at 7 to 9 km. above the earth's surface. It is probable that the gradient continues to augment until a maximum is reached and then diminishes.

As the sounding of atmospheric electricity is not at present possible at heights of 20 to 30 km., when the temperature can still be registered automatically, we do not possess experimental means above 9 km. for determining the condition of the ionization of the atmosphere. The layer of maximum ionization due to ultra-violet radiation can be estimated approximately at 50 km. altitude where the atmospheric pressure is a little less than one millimeter and corresponds to the pressure at which the potential of a spark in the air is minimum in ordinary experiments with vacuum tubes. This layer is situated in the stratosphere[12], not far from the hydrogen sphere; the region in which these corpuscles are mostly captured is probably in the hydrogen sphere and in the geocoronium of Wegener, if it exists at heights of 200 to 500 km. It is generally in the equally elevated spheres of the atmosphere that auroral discharges occur, as amply proved by measurements made by Norwegian observers.

The ionization due to ultra-violet rays being chiefly confined to the relatively low region, the recombination of the ions will take place very rapidly, as soon as the ionizing cause ceases to operate. This effect therefore, is observed particularly at the approach of the rising and the setting of the sun.

The ionization of the upper atmosphere being governed by these two causes. It is natural to suppose the existence of an ionized layer not far from the earth's surface, which, during the day, is probably found at a height equal to about the hundredth part of the terrestrial radius, and during the night of variable length, according to solar conditions, at a height more than double the preceding. The position of this layer, however, is not well defined geometrically, for the transition is not made suddenly; it is only with reference to the average layer that we will draw conclusions hereafter.

The existence of such a layer must provoke an absorption as well as a reflection of the incidental electric waves. The reflection by this ionized layer will be analogous in its general features to that of sound reflection by clouds, curtains, dense thickets, and will form a sort of "gallery of murmurs" around the earth. This last analogy was expressed by Eccles[13].

A portion of the electric wave arriving at the ionized layer will be equally transmitted across it, so that the energy emitted by the exciter will be propagated in part in space, in part in the envelope comprised between the earth and the ionized layer. The density of the energy of the electromagnetic radiation in such an envelope decreases in a manner inversely proportional to the distance of the exciter and not inversely to the square of the distance, as in the case of propagation in space of three dimensions. Although the coëfficient of transmission across the ionized layer may not be known, the preceding law for the decrease of energy with distance should be approximately exact. Sommerfeld[14] has discussed the existence of the superficial wave whose energy decreases according to the law of inverse proportion, as for the propagation in the envelope. It is generally accepted that series of waves are propagated in the manner first indicated by Hertz with his double exciter; but if we suppose the existence of a reflecting layer at a distance equivalent to twenty or thirty wave-lengths, the mode of propagation becomes much more complicated, because of multiple reflections due to the ionizing layer and the surface of the earth, in such sort that the curving of the wave according to the curvature of the earth is a problem whose nature is not easy to explain by diffraction, by surface wave, nor by augmentation of speed of propagation in the upper portion of the atmosphere. The existence of these phenomena cannot be doubted, but opinions differ as to their relative importance. The hypothesis of the ionized layer gives great aid to the explanation not only of these phenomena, but also to divers aspects of wireless telegraphy.

It might seem at first that during the day the ionized layer is subject to variations depending on the weather. Quite near the earth's surface the intensity of solar light is extremely variable, because of precipitations in clouds and fogs and the distribution of particles of dust in the air. Observation shows that the height where the ultra-violet end of the solar spectrum is absorbed is outside the troposphere, and probably much above the isothermic layer, a hypothesis in accord with the strong absorption of Schumann rays in laboratory experiments. The variation noted is due solely to the change of intensity of solar light, which, though inconstant, is not so frequently subject to the perturbations caused by the corpuscular emission resulting from solar activity. This proves necessarily that the position of the ionized layer is more constant during the day than during the night.

In adopting the preceding conclusion, we can represent the section of the ionized layer in the east-west direction by curves like those of Figures 1 and 2. The transition from higher to lower altitudes or *vice versa*, at the rising and setting of the sun, is not discontinuous, but takes place very rapidly, so that there is an abrupt change of the curve of the surface. During this stage the electric waves coming from B (far to the west of A), are reflected by the concave surface of the layer of transition and concentrated towards the station A (at the east), when sunrise approaches, producing a transitory maximum effect (Fig. 1). Probably during this process there is formed a caustic of electric rays.

When this sheaf of rays directs itself towards the lower layer after reflection by the terrestrial surface there is produced a transitory minimum if A is in such position that it borders on the angle of the ionizing layer (not represented in the figures). Therefore, at the station A, receiving the signal from B, there will be a maximum effect followed by a minimum effect before and after sunrise. At sunset, the curve during the transition, is turned in the inverse direction, and is not favorable to the reflection. We can perceive a slight maximum effect due to the diffraction at the angle, but some time after sunset the electric waves are reflected farther towards the top, so that there is produced an implied minimum (Fig. 2). In receiving the signals from A to B the effect will be perceived in the inverse order. Note that the signal from A, some time before sunrise, will be partially concentrated by the concave reflecting surface towards a station distant by many multiples of the height of the layer, while no similar action is noted after sunset.

*From *Revue Generale des Sciences*.

[1] Fitzgerald: British Association, 1893.

[2] Heaviside: Theory of Electric Telegraphy: Encyc. Brit., vol. 33, p. 215; 1902.

[3] Kennelly: *Elec. World*, 1902.

[4] Ch. Ed. Guillaume: Rev. Gen. d. Sc., vol. xv, p. 165, 1904.

[5] Birkeland: Norwegian expedition for the study of aurora borealis, 1901, and various memoirs in the C. R. of the Ac. d. Sc. of Paris.

[6] Störmer: Arch. d. Sc. phys. et nat., vol. xxiv, pp. 5, 113, 221, 317 (1907); various memoirs in the C. R. d. Ac. d. Sc., especially Oct. 26, 1908.

[7] Arrhenius: Trans. of Internat. Elec. Cong. St. Louis, vol. I. p. 272 (1904).

[8] Nagaoka: Proc. Tokio math. phys. Soc. vol viii, p. 397 (1914).

[9] Dorno: Light and Air of High Mountains, 1911.

[10] Wigand: Ber. d. deutsch. physik. Gesells., vol. xv, p. 1090 (1913).

[11] Wigand: Ibid. vol. xvi, p. 232 (1914).

[12] Wegener: Thermodynamics of the Atmosphere, 1912.

[13] Eccles: Proc. Royal Soc. A, vol. lxxxvii, p. 79 (1912).

[14] Sommerfeld: Ann. der phys. vol. xxviii, p. 665 (1909).

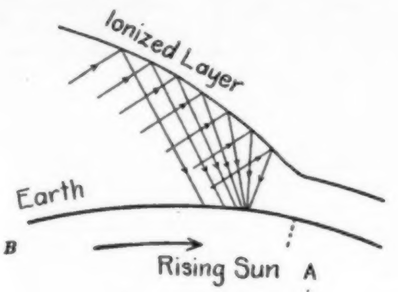


Fig. 1.

When the sending and receiving stations are separated by such layers of transition, the effect on the signals is very complicated; it depends above all on the height of the ionized layer in the dark.

As the ionized layer is found very low during the day the electric rays are reflected many times, and at each reflection they are dispersed, transmitted across the layer, and absorbed to a certain degree; the result is that the waves are much mixed, and that their effect is much lessened. During the night the ionized layer is more variable than during the day, and it is impossible to deduce definite conclusions. In general, because of the great altitude of the reflecting layer, the waves can be freely propagated, and as the number of reflections is much less than during the day, there are fewer losses in transmission from one station to another. The reflecting layer is mostly composed of electrified corpuscles mingled with highly attenuated matter; also the reflecting power is higher than that due to ultra-violet rays. Hence, in general, signals can be transmitted much better at night, a fact well known in practical wireless telegraphy. The result of the preceding discussion can be conveniently represented by the diagrams Figures 3 and 4, which accord roughly with those given by Marconi for transatlantic communications.

I have supposed the reflecting layer to be as well united by day as by night; but this is only a first approximation. The layer, being very low during the day, must be subject to weather influences, and presents local corrugations, as have been often observed since by Helmholtz in the "waves of the wind."

The existence of these folds is a great obstacle to wireless transmission, for they generally give rise to a diffraction. To avoid such an effect, it is preferable to work with waves whose length is either much greater or much less than the length of the fold. Perhaps the advantage gained with the long waves during the day is because of this.

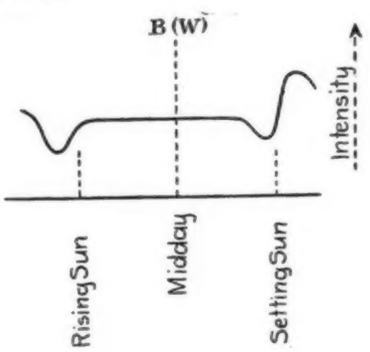


Fig. 3.

At night the capture of the corpuscles is of a complex nature, as is shown by Störmer's diagrams, and the dimensions of the folds are much greater; hence it is advantageous to use relatively short waves to avoid the effect of diffraction and receive a regular series of waves. For a given condition of the ionized layer there is an optimum wave-length to be employed. There may be other causes which justify the use of long waves by day and short ones by night; but the occasional appearance of stray waves seems chiefly due to these folds.

It has been asked whether the rarefied gases of the upper atmosphere share in the rotation of the earth, as if they were rigidly attached, or not; the enormous speed of the silvery clouds observed at a height of forty to fifty kilometers after the eruption of Krakatoa is in favor of the second hypothesis. If these folds or corrugations of the atmosphere are formed in regions sufficiently elevated to be partially detached from the rotation of the earth, then the reflection from the folded surface would present slight maxima and minima at alternate intervals; this is what is generally noted in the observation of stray waves.

Then a phenomenon resembling the fringes of the aurora borealis is presented at times in the corpuscular distribution of the upper atmosphere, and contributes to the formation of stray waves. The existence of such a phenomenon is supported by spectroscopic observations of the clear sky, in which the lines of krypton are found, as they usually are also, in the spectrum of the aurora.

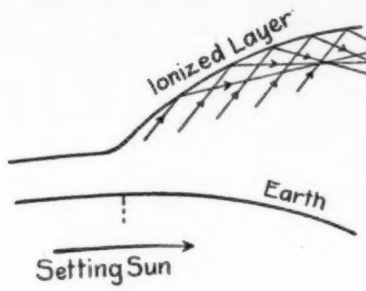


Fig. 2.

Concerning wireless transmission on different parallels, it must be remarked that in high latitudes the ionization due to electrified corpuscles is extremely complicated in the vicinity of auroral zones, so that the form of the reflecting surface described above is but a rough approximation. The complexity thus introduced by the accumulation of corpuscles at a single point doubtless increases the difficulty of communication in polar regions.

The equatorial zone, on the contrary, is not subject to so complex a distribution of corpuscles. If we may rely on the experiments of Birkeland and the calculations of Störmer, the existence of a band of corpuscles near the equator is no obstacle to communication, for the reflecting layer is not greatly altered. It is very probable that up to a certain distance from the equator transmission in the east-west direction is easier than in the north-south direction, the layer being more united in the direction of the parallels than in that of the meridians. But it must not be forgotten that in the equatorial zones the frequent and violent perturbations of atmospheric electricity compensate, and more, the actions of the reflecting layer, so that observations must be interpreted from another point of view, which does not come within our present scope.

As for wireless transmission in the direction of the meridian (N.-S.), the section of the reflecting layer does not change its curve suddenly, so that transmission ought to be much easier than in the direction E.-W.

At the approach of sunrise or sunset the waves will be reflected laterally, which will weaken the effect of the signals. This is a disadvantage, but wireless communication at a great distance is generally more favorable in the meridian direction than in that of the parallels.

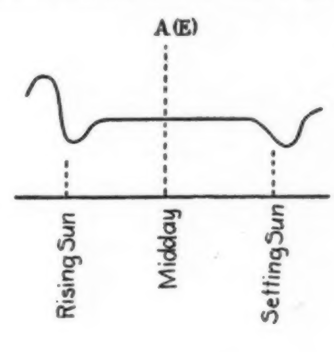


Fig. 4.

This seems to be confirmed by the transmissions between Ireland and South America.

As for seasonal variations in the intensity of signals it must be remarked that except in high latitudes the position of the ionized layer does not vary much in the course of the year, and that variations occur only at night. According to Mosler[15], there will be two maxima and minima in the intensity of signals in the course of a year. These doubtless bear a direct relation to the capture by the earth of electrified corpuscles, but other subsidiary causes, such as experimental arrangements, probably contribute to this effect, so that it would be premature to attempt to a theory on the subject in the present state of our knowledge.

From the preceding discussion it is clear that the sun is the principal cause of various phenomena which accompany wireless transmission. According to H. Ebert the electric oscillation of the sun possesses a period proper to itself of 6½ seconds. It seems very probable that during the period of great solar activity the electric excitation of the sun can propagate itself in the universe in the form of electric waves. In this case wireless operators will sometimes receive spontaneous signals in accord with the solar vibration. If this wave was transmitted across the ionized layer and thus observed, it would be a great contribution to astrophysics, which would open the way to the perception of the electric pulsation of the sun and would be an efficacious aid in discovering the condition of the ionized layer. The difficulty resides in the adjustment of the antennae to the reception of waves of so long a period. Up to the present we have experimented with waves excited on the surface of the earth and reflected by the inferior surface of the ionized layer. If the electric wave of the sun can really be observed on the earth's surface it is the wave transmitted across the ionized atmosphere. The importance of such a study for our knowledge of the sun and of the manner in which the atmosphere is ionized would be considerable.

The effect of solar eclipses on wireless transmission can be likewise explained very simply.

It would seem that if the corpuscles move in a straight line towards the earth the arrival of the ionizing agent is temporarily suspended during the eclipse, and that the effect ought to be perceived in the intensity of the transmission. But, as we have already seen, the corpuscles follow extremely complicated trajectories before reaching the earth, so that their number is not much affected by the interposition of the moon between the earth and the sun, as Störmer's curves easily prove. The alteration of the ionization of the atmosphere is effected by the interception of the solar light. The ionized layer rises gradually in the upper regions until totality of the eclipse is reached. This is confined to a narrow region of shadow and lasts only a few minutes; but, as the recombination does not take place instantaneously, the totality will have already passed before a definite modification has been produced in the ionized layer, and the layer will gradually resume its position on issuing from the penumbra. Hence a slow alteration in the intensity of the signals will be produced, due to the disturbance in the ionized layer, probably giving birth to a slight fold. The transverse section of the ionized layer during a solar eclipse takes the form indicated in Fig. 5. The part of

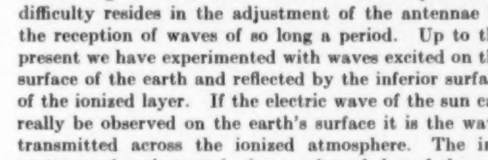


Fig. 5.

the layer lying in the penumbra will be slightly concave towards the earth, with a slight fold above the region of totality. The duration of the totality being usually less than seven minutes the recombination of ions will never be completed in so short a period; also the result of the interception of the light suffices to explain the appearance of a fold in the portion of the ionized layer where the cone of shadow strikes the earth. The perturbations of the ionized layer will cause a slight action of concentration towards the position of the total eclipse, if the transmission of electric waves takes place transversely to the line of the eclipse. By employing the same kind of reasoning as in the discussion of the effect of sunrise and sunset, it is evident that the intensity of the signals will be weakened at the beginning of the eclipse, will increase in strength, attain a maximum, then gradually decrease.

Fig. 6.

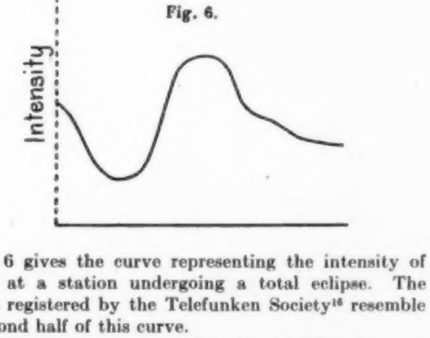


Figure 6 gives the curve representing the intensity of signals at a station undergoing a total eclipse. The records registered by the Telefunken Society[16] resemble the second half of this curve.

It is necessary to remark that when eclipses occur in seasons of great disturbance of atmospheric electricity the effect attributable to the eclipse would probably be masked, so that no definite result could be obtained. I do not yet know the observations relating to the effect of the eclipse of August 21, 1914, but it seems to me very probable that no one has as yet drawn any conclusion from the observations made at the different stations, even if they have not been troubled by the war, for the month of August was affected by very great seasonal variations, whose principal cause is atmospheric electricity.

[15] Mosler: Electrotech. Zts., No. 35, 1913.

[16] *Telefunkenzeitung*, No. 6, p. 89 (1912).

An Enlarged Electron of Practical Size: The Faraday*

By Carl Hering

It is the fashion today to talk in terms of electrons, the entities which compose the atoms. Physicists tell us that the smallest atoms are about one-three-hundred-millionth of an inch in diameter, and the largest not many times this; that there would have to be a row of about two hundred of them to form something large enough to be visible in the most powerful microscope known; that if a drop of water were enlarged to the size of the earth, the atoms in it would be about the size of a baseball; that helium gas contains 77 billion-billion atoms per cubic inch, presumably meaning at atmospheric pressure. And still further straining our abilities of conception, they tell us that the negative electrons, which are supposed to be all alike, are about a one-hundred-thousandth part of an atom; that if an average atom were enlarged to a sphere 100 yards in diameter, the electron would be about the size of a pin-head, though its density is said to be a million-million times that of the atom.[1]

Such staggering and bewildering figures, and the fact that they are not yet accurately known, make it impossible to talk quantitatively about electrons in practice, yet if the engineer is supposed to deal with electrons he must know something more precise about the quantity of negative electricity which an electron represents.

The chemist who has had to deal with these tiny atoms in a quantitative way, has solved this difficulty in practice by the ingenious and perfectly satisfactory and accurate method of imagining a practical substantial form of atom, or "life-size" atom, to consist of a certain number of millions of the real atoms; the exact number is not known nor is it necessary to know it, as long as all of them have been increased exactly the same number of times. If the atomic weight of hydrogen is 1, then this aggregation or enlarged, practical atom is by definition such that it weighs 1 gram, and when the atoms of all the other elements are increased in number the *same number of times* the practical atoms will weigh as many grams as are represented of their atomic weights; these enlarged, practical atoms are the well known gram-atoms of the chemist, the gram-molecules being similarly defined. These practical atoms are quite substantial and workable amounts, being easily weighed and measured. Thus a gram-atom of copper weighs 63.57 grams, a piece of copper about the size of a large marble, and a gram-molecule of hydrogen under normal conditions measures 22.39 liters, or a little less than a cubic foot.

This ingenious and quite satisfactory scheme of the chemist to get over this difficulty naturally suggests that a similar method might be used to establish a substantial, workable, "life-size" electron. Fortunately a simple relation exists which makes this quite practical.

It is known from Faraday's law that an atom of every element requires exactly the same quantity of electricity to oxidize or reduce it electrochemically per unit change of valence, hence the gain or loss of the same number of electrons, whatever that number is. For the chemist's enlarged, practical gram-atom, it is known definitely that this quantity is equal to 96,494 coulombs or 26.80 ampere-hours, which is also a substantial, easily measured quantity, and like the gram-atom requires no straining of the imagination to conceive it; it is in fact a very large amount for a gram-atom to carry when we conceive that it means a charge which could cause a steady flow of nearly 27 amperes for one hour. This constant quantity has received the name of a faraday, and is now beginning to be referred to in literature by that name.

It will be seen therefore that if the constant (the unknown) quantity of electricity which is gained or lost when one real atom is oxidized or reduced electrochemically, be multiplied by the same (unknown) number that the real atoms have been multiplied by to make the practical gram-atoms, it will be equal to the faraday. Hence this definite quantity of electricity (the faraday) is obtained quantitatively in exactly the same way from the minute, unknown quantities of electricity, as the definite quantity of matter (the gram-atom) is obtained from the minute, unknown quantity of matter in a real atom, thus deducing a real, definite, substantial quantity from the realm of the unknown and inconceivable. Even another unknown quantity is eliminated thereby, namely the number of real electrons which a real atom gains or loses in being oxidized or reduced; this need not be known either in establishing these substantial, workable units in this way.

The faraday may therefore quite consistently and correctly be called a gram-atom-electron, or enlarged electron, or popularly, a life-size electron, and with this understanding this enlarged electron can be rationally and correctly used in calculations and in literature; and as its size is so inconceivably larger than the real electron, no confusion could ever arise in the intelligent mind as to whether the real or the enlarged electron is meant if the latter is referred to more briefly as an electron, just as the chemist may and often does refer briefly to the atom when he really means the enlarged gram-atom.

Thus it is quantitatively correct to say that a gram-atom of hydrogen (1.008 grams) loses one enlarged electron (one faraday or 26.8 ampere-hours) on being reduced, or that one gram-atom of iron (55.84 grams) gains three enlarged electrons (3 faradays or 80.4 ampere-hours) on being oxidized from iron to the ferric state. Each of the + and — signs often placed over the symbols of atoms showing the free charges carried after dissociation, and every unit of valence, therefore represents an enlarged electron of one faraday if the symbol represents a gram-atom. Similarly each bond then represents quantitatively the attraction of one negative faraday or enlarged electron on one element to one positive electron on the other.

Whether chemical reduction is a loss of negative electrons, as stated above, or a gain, is perhaps still controversial, and not yet proved physically; whichever it is, oxidation is the exact reverse; this does not affect what has been said above about the quantity of the enlarged electron, but merely the direction of its flow. At present the opinions are deduced from arguments involving the definition of what the real processes of reduction and oxidation mean; the writer considers that the true reduction occurs during the decomposition or dissociation of a compound, while some others consider it to occur when the element of an already decomposed or dissociated compound is finally set free. The writer cites the case of reducing the iron in ferric compounds to ferrous, which is a true reduction, yet no iron has been set free. This subject was discussed more fully in an article by the writer on "Oxidation and Reduction in Physical-Chemistry—Consistency of Terms and Conceptions," published in the May 1st issue of *Metallurgical and Chemical Engineering*, page 507.

*From *Metallurgical and Chemical Engineering*.

[1] Comstock and Troland, "The Nature of Matter and Electricity."

A Canvas-attacking Fungus

So many inquiries have been made from strangely diverse sources, especially since the outbreak of war, concerning black spots which appear on bell-tents, sails, aeroplane and airship fabrics, etc., that it seemed desirable to write the present note principally to direct attention to a paper by F. Guéguen in *Comptes Rendus*, Vol. clix. (1914), p. 781, "Sur l'altération dite 'piqûre' des toiles de ténte et des toiles à voile." The spots are caused by fungi which damage the fabric, so that after some months it is easily torn. The fungus hyphae grow on the surface of the fabric, between the fibers and within the lumen of the fibers. Guéguen found that the fungi principally concerned were the Pyrenomycetes, *Pleospora infectoria* and *P. herbarum*, especially the former. These Ascomycetes are also found in their conidial states, *Alternaria tenuis* and *Macrosporium commune*, and other Mucedineae, Rhinocladium, Helminthosporium, etc., are often associated with them. According to Guéguen, the malady is scarcely ever due to accidental contamination, but is caused by the development, in moist warmth, of molds already present in the newly manufactured fabric, commercial patterns of the most diverse origin being found almost all to contain fungus spores. Practically all unbleached canvas is affected, but that bleached with hypochlorites, etc., remains free—the glaucous colonies which are sometimes seen are due to Penicillium or Aspergillus derived from the air, and almost invariably non-injurious to the fabric. Guéguen holds that the fungi causing the spots are those which grow on the dead stems of the textile plant, which are introduced amongst the fibers at the time of retting. The thick-walled hyphae remain in a resting state in the dry canvas, and resume vegetative growth when external conditions become again favorable (humidity, warm, confined air). He considers that the best method of prevention would be to sterilize the tow after retting, by heat—steam under pressure, and then dry heat. Boiling solutions of salts of chromium or copper would also serve, applied either to the tow or the fabric. A suitable method of rendering awnings, etc., impermeable would be to immerse the fabric first in a 20 per cent solution of soap, and then in eight per cent copper sulfate, each at boiling point.

Similar black spots are very common on paper, and are most commonly due to Alternaria, Stachybotrys, and Chaetomium. Sée ("Sur les moisissures causant l'altération du papier," *Comptes Rendus*, Vol. clxiv. [1917] p. 230) has investigated the variously colored spots damaging paper, and believes that the causative fungi are already present in the paper-pulp, and probably come from the straw, fiber, etc., from which the pulp is made.

In the damaged fabrics examined by the writer the perfect Pleospora stage has rarely been found, though the Alternaria and Macrosporium conditions have been frequent. Other Mucedineae, Cladosporium spp., Stachybotrys, Helminthosporium, etc., were also common. In certain cases fungi were found, however, which seem to be identical with species which are known to occur in the soil. A large number of fungi are active cellulose destroyers; many of these occur only in the soil, and it seems probable that a large proportion, if not most, of the cellulose destruction which goes on there is brought about by their agency. Canvas left lying about on broken ground would be almost certainly attacked by these cellulose fermenters, given the suitable conditions for growth—a very small portion of soil scattered over moistened sterilized filter-paper gives rise to an amazing number of fungus colonies. Although no experiments have yet been undertaken in connection with this suggestion, it is put forward for certain more or less obvious reasons.—J. Ramsbottom, Department of Botany, British Museum, in *Nature*.

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